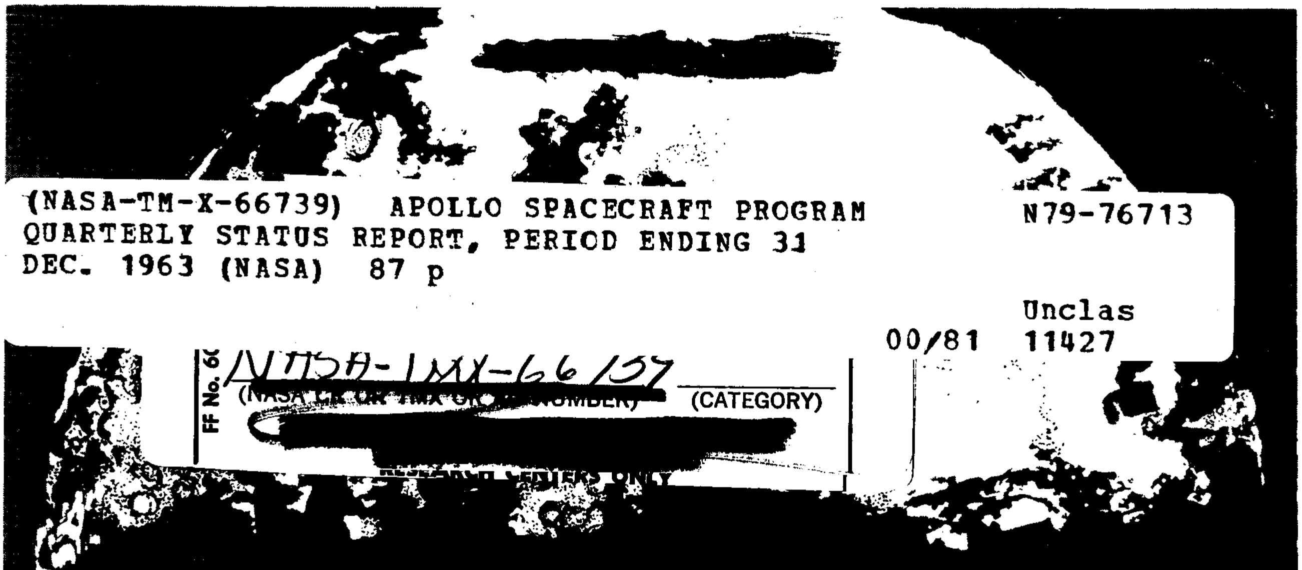

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT APOLLO

QUARTERLY STATUS REPORT

NO. 6
FOR PERIOD ENDING
DECEMBER 31, 1963

MANNED SPACECRAFT CENTER

NASA

CLASSIFICATION CHANGE

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROGRAM [U]

QUARTERLY STATUS REPORT NO. 6

FOR

PERIOD ENDING DECEMBER 31, 1963

By Manned Spacecraft Center

FOREWORD

This report is the sixth in a series of reports on the status of the Apollo Spacecraft Program for the manned lunar landing program. The fifth status report described the development of spacecraft modules and systems through September 30, 1963; this report reflects activities and changes in status during the fourth calendar quarter, 1963.

SUMMARY

The Apollo space vehicle consists of the spacecraft and launch vehicle as shown in figure 1. The spacecraft is the responsibility of the Manned Spacecraft Center (MSC), Houston, Texas, while the launch vehicle is being developed by the George C. Marshall Space Flight Center (MSFC). The Apollo spacecraft configuration is shown in figure 2.

The Apollo spacecraft is composed of three separable modules: (1) the command module (CM) which houses the crew from the earth to the vicinity of the moon and return to the earth, (2) the service module (SM) which contains the propulsion system as well as other systems, and (3) the lunar excursion module (LEM) which separates from the command and service modules when in lunar orbit and descends to the lunar surface for manned exploration.

The basic launch vehicle for lunar missions is the Saturn V, which consists of three stages: the S-IC, S-II, and S-IVB. The S-IC utilizes LOX-RP-1 propellants for five F-1 engines while the S-II stage uses LOX-LH_2 propellants for five J-2 engines. LOX-LH_2 propellants are used for the one J-2 engine in the S-IVB stage.

Major accomplishments of the Apollo Spacecraft Program during this reporting period were as follows:

(1) The Apollo pad abort test vehicle, boilerplate 6, was successfully launched from White Sands Missile Range (WSMR) on November 7, 1963. The flight demonstrated the capability of the launch escape subsystem. No holds were encountered during the countdown, and the boilerplate was launched on schedule at 9 a.m. MST. The launch escape tower and the forward heat shield jettisoned 15.6 seconds after launch at 5,600 feet, followed by drogue parachute deployment at 18.6 seconds after launch. The earth landing subsystem functioned normally, and telemetry indicated that all functions performed within design parameters as shown in table I and table II. No significant damage was sustained by the CM or the parachutes during the flight. The CM was returned to North American Aviation, Inc., (NAA) after the test to be used in parachute recovery system tests.

TABLE I.- BOILERPLATE 6 FLIGHT PARAMETERS

Parameters	Predicted	Actual
Altitude at tower jettison	4,900 feet	5,148 feet
Range at tower jettison	4,350 feet	4,292 feet
Maximum angle of attack	11 degrees	12 degrees
Maximum velocity (M)	Mach 0.7	Mach 0.66
Maximum dynamic pressure (q)	595 psf	519 psf

TABLE II.- BOILERPLATE 6 PAD ABORT FLIGHT SEQUENCES

Sequence	Seconds predicted	Seconds actual
LES δ pitch control motor ignition		
LES motor burnout	8.0	8.8
Tower and apex jettison	15.5	15.6
Drogue parachute deployment	18.5	18.6
Pilot parachute	23.5	24.0
Main parachute disreef	33.5	32.3
Command module landing	157.0	165.1

(2) A letter contract to design and manufacture the in-flight test system (IFTS) was awarded to International Telephone and Telegraph, Kellogg Communications System Division, Chicago, Illinois, during this period. The IFTS will enable the astronauts to isolate and identify possible subsystem and component failures and will provide greater reliability with less weight than mass sparing.

(3) As a result of extensive studies conducted during this quarter, the Grumman Aircraft Engineering Corporation (GAEC) will change from a four-tank to a two-tank LEM ascent stage configuration. This change will result in an approximate weight savings of 100 pounds (460 pounds effective weight), a 10-week schedule slip (based on contract negotiated schedule), and an increased cost between $1.5M and $2.5M. Significant advantages are a much simpler and reliable ascent propulsion propellant feed system, lower overall LEM center of gravity, and improved means of carrying loads between the ascent and descent stage structures.

(4) The dynamically stable injector program for the service propulsion subsystem has been initiated. This program, starting in mid-January and ending in October, 1964, consists of the fabrication and test of a series of two different types of baffled injectors. Performance, injector thrust chamber compatibility, and combustion instability tests will be conducted.

(5) All subassembly fabrication for the stabilization and control subsystem is complete and assembly is in process on boilerplate 14. Minor design changes are being incorporated as determined by FM "A" tests. Acceptance test completion and delivery are scheduled for February 15, 1964.

A stabilization and control subsystem control interface has been established with the S-IVB launch vehicle. The system rate gyros are being redesigned to provide 20°/second entry roll rates, and an auto-pilot cut-out switch is being provided. Complete redundancy of the thrust vector control (TVC) loop is in design status.

(6) The North American center probe and drogue docking concept has been approved as shown in figure 3. Operation of this concept is as follows:

Crew control of the spacecraft stabilization and control system (SCS) is employed to limit the impact conditions to those within the docking subsystem capability. The probe engages the spring latch without requiring stringent alinement or positioning of the modules. The attenuator compensates for axial velocity differences while the pitch arms and bungees compensate for lateral velocity and rotational differences. While the relative motions are nulled, the attenuator is depressed to cause the modules to engage latches suitable for maintaining an interface seal. The bungee loaded pitch arms provide modular alinement during this operation. After pressure hatch removal, the structural latches are manually operated, and the docking mechanism removed and stowed to accommodate crew transfer. During subsequent mission operations, the docking mechanism is reinstalled prior to separation of the modules to accommodate further docking operations. The mechanism is jettisoned along with the LEM in lunar orbit prior to the transearth injection.

(7) North American Aviation, Inc., has been provided revised crew-tolerance impact limits which provide for higher onset rates and lower peak values. The limits permit a choice between 1,000g per second and 20g as opposed to 500g per second and 25g. These revisions will allow tradeoff studies between peak value and onset rates to improve system designs presently restricted by onset rate limits.

(8) The problem of propellant grain cracking in the launch escape motors (launch escape subsystem) during temperature cycling between 140° F and -20° F was verified to be the result of moisture condensation due to improper sealing of the motor. The moisture degraded propellant strength and the grain could not withstand the stresses induced during temperature cycling. Thermal cycling tests with adequately sealed motors have indicated excellent grain integrity. A preflight visual inspection of all launch escape motor propellant grains has been incorporated in the vehicle flight program to provide absolute assurance of a satisfactory propellant condition.

SPACECRAFT SUBSYSTEMS DEVELOPMENT

COMMAND AND SERVICE MODULES

Guidance and Navigation System

The following major changes to the G and N System will be made beginning with G and N System 13 as the first Block II system. These changes were outlined to MIT/IL in December 1963.

Computer Block II.- Two complete, active computers each with the same capability as a Block I computer will be installed. Repackaging techniques and the removal of inflight maintenance capability give an estimated weight of 82 lbs for the combination as compared to 70 lbs for a single Block I or 128 lbs for a completely spared Block I computer. Both Block I and Block II computers will have more than a 24,000-word permanent memory capacity allowing greater than a 90-percent capacity above current estimates.

Coupling Display Units (CDU) Block II.- A savings of weight and better reliability will be obtained by replacing the electromechanical units of Block I with the electronic CDU's.

Inertial Measurements Unit (IMU) Block II.- The Block II IMU is reduced from 14 in. to 12.5 in. in diameter by utilizing smaller resolvers and gimbals with the same stable member. The Block II unit is expected to weigh 42 lbs, an 18-lb reduction from the Block I IMU weight.

A recovery program to qualify the Computer Display Keyboard (DSKY) panel electroluminescent lights was initiated. Qualification tests are to be completed by July 25, 1964. Class B (unqualified units) units will be provided for G and N systems where required to be followed by a Class A retrofit.

Studies by OMSF and Bellcomm indicated that modification of the Saturn V instrument-unit guidance computer for use in the LEM and CM G and N systems would be feasible. A backup development program utilizing the Saturn V computer high-reliability approach is planned to be initiated the next quarter.

In order that lack of programing information will not be a constraint on computer delivery, the following procedure will be followed.

The Block I computers will be delivered less the permanent rope memory modules. Interim test ropes for each system will be provided. Flight rope memory modules will be partially assembled and stocked until program information is available. When program information is available, final assembly of ropes will be made and they will be delivered to the designated Apollo guidance equipment.

Problem areas during the next quarter are expected to completely define Block II systems and develop firm development and manufacturing schedules. In addition, a new set of interface control documents must be coordinated between MIT/IL and NAA covering Block II equipment.

Stabilization and Control Subsystem (SCS)

Subsystem Development Status.- The first engineering model (functional model A (FM "A") of the SCS) completed fabrication and assembly and satisfactorily completed component tests and system tests. Acceptance tests were completed, but revealed some "out-of-tolerance" conditions. Rework is in progress with retest completion and delivery scheduled for January 15, 1964.

Fabrication and assembly of all end items for the FM "B" SCS were completed and component tests completed. System tests are in progress with acceptance tests completion and delivery scheduled for February 1, 1964.

All subassembly fabrication for the boilerplate 14 SCS is complete, and assembly is in process. Minor design changes are being incorporated as determined by FM "A" tests. Acceptance test completion and delivery are scheduled for February 15, 1964.

Subsequent systems are on schedule in fabrication and assembly, and all parts procurement orders have been placed.

FM "A" and FM "B" bench maintenance equipment (BME) fabrication and assembly are complete. Required rework is in progress as a result of compatibility testing with actual systems. Delivery of FM "B" BME is expected concurrent with delivery of FM "B" SCS.

Allied development accomplishments are as follows:

a. The requirements for the AFRM 009 programer sequencer for the unmanned, suborbital flight were completed by NAA.

b. The SCS wiring diagram for boilerplate 22 was completed.

c. The SCS installation drawings for AFRM 009 were completed.

d. The SCS test requirements for AFRM 008 were completed.

e. The SCS wiring lists and system schematics for boilerplate 14 were released.

f. The revised SCS Procurement Specification (superseding the January 28, 1963, version) has been completed and in process of release.

g. The revised SCS design specification (superseding the March 22, 1963, version) was released.

<u>Weight Status</u>.- The current status is 222.6 lb (not including in-flight spares (35 lbs) or hand controller cabling (4.9 lbs), based on actual hardware weight). Ultimate total system predicted weight is between 182 and 206 lbs, including spares.

<u>Power Status</u>.- 14 day mission

Target: DC: 175 watts, max; 44 KWH total
AC: 144 watts, max; 23 KWH total

Present: DC: 180 watts, max; 43 KWH total
AC: 144 watts, max; 23 KWH total

Major Design Changes.- An SCS control interface has been established with the S-IVB. The system rate gyros are being redesigned to provide 20°/sec entry roll rate capability. An autopilot cutout switch is being provided. Complete redundancy of the thrust vector control loop is in design status.

Earth Landing System

To summarize the Earth Landing System to date, the following tables are presented: Table III, Parachute Development Tests; table IV, Boilerplate Tests; and table V, Solid Canopy Development.

The first test with boilerplate 19, which was the sixth boilerplate drop, repeated those conditions in which boilerplate 3 failed. The recommended fixes resulting from the boilerplate 3 failure were included and this test in support of boilerplate 6 pad abort was very successful. Boilerplate 6 pad abort test included the same parachute systems' modifications.

The seventh and eighth boilerplate 19 drop tests were successfully completed. These tests were in support of the boilerplate 12 high dynamic-pressure abort test to be conducted at WSMR. Drogue deployment from the CM apex forward trim point was tested to 100 psf dynamic pressure.

The series of four parachute test vehicle (PTV) tests designed to investigate the feasibility of two simultaneous deployed drogues were successfully completed. Boilerplate 19, test 9 incorporated the two simultaneous drogues which were deployed from an apex forward attitude. Damping of the CM with two drogues was found to be better than predicted. Test 9 conducted December 18, 1963, was successfully recovered.

Detail design and evaluation have shown that the rigid yoke concept for replacement of the parachute harness system is not feasible. This concept has been replaced by a fabric bridle with protective covering.

Eight impact tests were conducted during this reporting period. Previous computer predictions of the impact capability envelope were checked by boilerplate impact tests. It was found that the testing and computer prediction did not coincide and repeatability of test conditions with satisfactory results was not accomplished. This has resulted in the soil impact capability envelope being reduced by 20 fps horizontal velocity. A more detailed analysis is being exercised.

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TABLE III.- PARACHUTE DEVELOPMENT TESTS

Test no.	Date of test	Drop vehicle	Configuration	No. of parachutes	Remarks
1	7- 5-62	Wt. bomb	88.1' Ringsail PDS 808	1	Test successful.
2	7- 9-62	"	" " "	1	Parachute damaged; split 2 places, vent to skirt.
3	7-19-62	"	" " "	1	Parachute damaged; split 1 place, vent to skirt, incl. bands
4	8-14-62	"	" " PDS 926 S/N 1	1	Test successful; minor damage.
5	8-22-62	"	" " PDS 926 S/N 2	1	" " "
6	9- 4-62	"	" " PDS 1226 S/N 1	1	" " "
7	9-14-62	"	" " " S/N 4	1	" " "
8	9-20-62	"	" " " S/N 2	1	Moderate damage.
9	10-11-62	"	" " " S/N 3	1	Test successful; minor damage
10	10-22-62	"	" " PDS 927 S/N 2R1	1	Extensive damage; premature disreef.
11	10-26-62	"	" " " S/N 4	1	Moderate damage.
12	11- 1-62	"	" " PDS 1226 S/N 5	1	" "
13	11- 7-62	"	" " " S/N 6	1	Test successful; light damage.
14	11-14-62	"	" " " S/N 7	1	Major damage; partial inflation.
15	11-20-62	"	" " " S/N 11	1	Test successful; light damage.
16	11-27-62	"	" " " S/N 10	1	" " " "
17	12- 4-62	PTV	PDS 1226	3	Deployment sequence OK; one parachute collapsed after inflation due to malfunction; very light damage; test successful.

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TABLE III.- PARACHUTE DEVELOPMENT TESTS — Continued

Test no.	Date of test	Drop vehicle	Configuration	No. of para- chutes	Remarks
18	1-11-63	Wt. bomb	88.1' Ringsail PDS 1544	2	Test successful.
19	1-18-63	PTV	Drogue parachute	1	Test successful
20	1-23-63	Wt. bomb	88.1' Ringsail PDS 1543	2	Test successful; reduced aero. interference.
21	1-28-63	"	" " PDS 1650	2	Test successful; some aero. interference.
22	2- 4-63	"	" " PDS 1543	2	Test successful.
23	2- 6-63	"	" " PDS 2021	1	Test successful.
24	2- 8-63	"	" " PDS 1543	2	Test successful.
25	2-15-63	"	" " "	2	Test successful.
26	2-20-63	PTV	13.7' Reefed ribbon para- chute	1	Test successful.
27	3- 1-63	PTV			Failed to arm events controller.
28	3- 8-63	Wt. bomb	88.1' Ringsail PDS 1543	3	Test successful.
29	3-14-63	PTV	" " "	3	Test successful; some aero. interference.
30	3-21-63	PTV	" " "	3	" "
31	3-25-63	PTV	Drogue parachute	1	Major damage; high q deploy.
32	4- 2-63	PTV	Drogue parachute PDS 845	1	Test successful.
33	4- 4-63	PTV	88.1' Ringsail PDS 1543	3	Test successful; some aero. interference.

[redacted]

TABLE III.- PARACHUTE DEVELOPMENT TESTS – Concluded

Test no.	Date of test	Drop vehicle	Configuration	No. of para-chutes	Remarks
34	4-22-63	Wt. bomb	87.9' Solid/Ringsail PDS 2072	1	Test successful.
35	4-24-63	"	" " "	1	Test successful; minor damage.
36	4-29-63	"	" " "	1	Test successful; minor damage.
37	5- 6-63	"	" " "	1	Test successful; minor damage.
38	5-10-63	PTV	Drogue parachute PDS 2119	1	Test successful; minor damage.
39	5-13-63	Wt. bomb	88.1' Ringslot/Ringsail PDS 2071	2	Partially successful; one parachute split from vent to skirt.
40	5-15-63	"	87.9' Solid/Ringsail PDS 2072	2	Failed riser on one parachute; other damaged & failed on disreef.
41	5-24-63	PTV	Drogue parachute PDS 2119-501	1	Test successful.
42	6-28-63	Wt. bomb	87.9' Solid/Ringsail PDS 2072	2	Partial success; aero. interference; one parachute failed at disreef.
43	8- 9-63	PTV	Drogue parachute PDS 2119	2	Test successful.
44	8-27-63	PTV	" "	2	Test successful.
45	10- 3-63	PTV	" "	2	Test successful.
46	11- 5-63	PTV	" "	2	Test successful; vehicle rotated with fins.

[redacted]

[redacted]

TABLE IV.- BOILERPLATE TESTS

Test no.	Date of test	Drop vehicle	Configuration	No. of para-chutes	Remarks
1	5- 3-63	Boiler-plate 3	Boilerplate 6 pad abort	3	Test successful.
2	5-16-63	Boiler-plate 3	Boilerplate 6 pad abort (Apex forward), q = 25 psf	3	Test successful.
3	6-12-63	Boiler-plate 3	Boilerplate 6 pad abort (Apex forward), q = 40 psf	3	Test successful; some aero. interference.
4	8-22-63	Boiler-plate 3	Nominal Reentry	3	Test successful; mains deployed around drogue.
5	9- 6-63	Boiler-plate 3	Boilerplate 6 pad abort (Apex forward), q = 25 psf	3	Vehicle destroyed; one pilot parachute and two mains failed.
6	10-22-63	Boiler-plate 19	Boilerplate 6 pad abort (Repeat drop no. 5)	3	Test successful.
7	11-15-63	Boiler-plate 19	S/M boilerplate 12 (Apex for-ward), one drogue failure	3	Test successful; large C/M oscillations.
8	12- 5-63	Boiler-plate 19	S/M boilerplate 12 (Apex for-ward), one drogue failure	3	Test successful; large C/M oscillations.
9	12-18-63	Boiler-plate 19	Dual drogues, single point attach., condition same as no. 7	3	Test successful; reduced C/M oscillations.

[redacted]

TABLE V.- SOLID CANOPY DEVELOPMENT

Test no.	Date of test	Drop vehicle	Configuration	No. of para-chutes	Remarks
1	4-18-63	Wt. bomb	82.5' Pioneer solid	1	Test successful.
2	4-23-63	"	" " "	1	Test successful.
3	5- 3-63	"	" " "	1	No deploy – static line failure.
4	6- 7-63	"	" " "	2	Aero. interference; one parachute failed at disreef; minor damage to other
5	6-28-63	"	" " "	2	Premature drop; parachutes demolished.

Structural Subsystems

Loads.- A detailed study is underway at NAA to define the launch escape system (LES) plume impingement loads as a function of thrust, angle of attach, and Mach number.

NAA has completed a study of the effect on the SM propellant due to simultaneous cutoff of all engines during first stage boost. Results of these analyses indicate that this condition is not critical for the spacecraft, and further analysis of the condition is unwarranted.

Command Module Structure.- The CM inner structure design is essentially complete for the Block I vehicle. Studies are underway at NAA on a number of changes proposed to be effective on the first of the Block II vehicles. These changes include shortening of the docking tunnel and flattening-off of the forward compartment heat shield to incorporate a jettisonable external docking concept. Other potential changes are relocation of the forward pitch control motors, redesign of the side hatch opening mechanism to allow extravehicular activity, and incorporation of a jettisonable boost protection cover. The inner structure for AFRM 006, the first vehicle in fabrication, is approximately 50 percent complete and six weeks behind the MDS-7 schedule.

Service Module Structure.- The SM structure design is essentially complete for the Block I vehicles. Block II SM will be very similar to the Block I design. Changes will be primarily of a "product improvement" type; that is, removal of scar weight, et cetera.

The structure for AFRM 001 is essentially complete and has been removed from the fabrication area. The structure for boilerplate 18 was 50 percent complete when deleted from the program due to the general revision of the flight plan. Disposition will be determined during the next reporting period. The structure for boilerplate 27 is 25 percent complete. Detail parts are in work for several other SM.

Crew Equipment Subsystem

Providing the spacecraft with food that could be eaten in liquid or semi-liquid form during emergency pressurized operation is being considered. This will permit a considerable reduction in the diameter of the emergency feeding port in the helmet visor.

MSC has directed NAA to assign the following parameters to the CM bioinstrumentation telemetry channels for early manned flights:

a. ECG – first axis (time shared with blood pressure)
b. ECG – second axis

c. Respiration
d. Temperature – periodic oral

The preceding parameters will be obtained simultaneously on any one crew member with switching from man-to-man for monitoring the entire crew. The number of parameters will probably be reduced on later flights.

All design control and procurement specifications for the displays and controls subsystem of the CM have been released by NAA.

Environmental Control Subsystem

NAA submitted a plan of action to provide cooling redundancy for critical electronic equipment in order to allow a safe return should the primary water-glycol heat-transport loop fail. The plan provides for consideration of two methods of cooling for the critical components, redundant glycol-cooled coldplates and water-boiling coldplates. The final decision regarding the proper approach will be made following specific determination of which critical components require cooling. It is presently planned that this change will be made at the Block II change point.

MSC Engineering and Development is presently evaluating heat rejection by urine boiling in the command and service module (CSM). Urine utilization would allow transfer of an equivalent amount of water to the LEM in lunar orbit, thus reducing the spacecraft injected weight. A prototype glycol evaporator was obtained from AiResearch for this purpose. It appears now that solids removal would be required; investigation of purification methods is in progress.

MSC Engineering and Development is investigating redesign of the environmental control system (ECS) space radiator to minimize water boiling for heat rejection. A significant reduction of water required for heat rejection in the CSM would enable transfer of an equivalent amount to the LEM in lunar orbit with a corresponding reduction in spacecraft injected weight. The present radiator capacity is limited by freezing under minimum load conditions.

MSC requested that NAA evaluate the application of thermal coatings to the CM exterior to relieve heat load requirements for the ECS cabin heat exchanger. NAA is now proposing to provide such coatings as well as appropriate insulation which will be protected from boost heating by the extension of the docking system boost protection cover. Preliminary analysis indicates such an action will enable the present heat exchanger to maintain the required 70° F to 80° F cabin temperature during all mission phases.

NAA has proposed to add an active thermal control system to the SM to maintain satisfactory temperatures in the propulsion systems. The proposed system consists of two water-glycol heat transport loops with appropriate nuclear heaters and radiators. MSC has directed NAA to proceed with the preliminary design of and recommendations for a system for earth orbit only. Approval of an active system for the lunar landing spacecraft has been deferred pending comprehensive review of requirements by MSC.

Construction of the test facility for the unmanned portion of the ECS integrated systems test is essentially complete. The test system was delivered to NAA by AiResearch, and installation in the test spacecraft has begun. Start of the actual testing for both the unmanned and manned phases of the program has again been delayed. The manned test start date was delayed due to contractual considerations of a NAA request for CCA for the program. The unmanned test was delayed by facility completion slip. Despite the slips, the schedule still does not appear critical.

Electrical Power Subsystem

Power Distribution.- Tests conducted by Pratt and Whitney indicate that the a.c. output impedance of the fuel cell, at the inverter ripple frequencies, is approximately 50 milliohms. This output impedance combined with the wiring impedance will result in a peak-to-peak inverter input ripple of approximately 1 volt, which is in excess of the 0.25 volt specified. Subsystem engineers at NAA have been advised of the expected ripple voltages. Actual value of ripple voltages will be determined by electrical power system breadboard tests. Subsystem compatibility with the bus voltage ripple will be verified by boilerplate 14 system tests.

Fuel Cells.- Significant progress in accumulating long test times on load without malfunction has been made during the last quarter. The following are highlights of the recent test effort:

a. A six-cell stack was run continuously for $2\frac{1}{2}$ simulated Apollo mission duty cycles or 1,000 hours.

b. A 31 cell stack was run on load for 400 hours, which is the specification life requirement.

c. An independent module was run for 166 hours of self-sustained load in vacuum.

d. An independent module was run 215 hours on load.

e. An independent module completed 12 consecutive restarts.

Additional development on the "L" shaped Teflon seal to improve seal "creep" and stability characteristics is being conducted. Recent tests indicate that KOH electrolyte leakage has essentially been eliminated. Design modifications that have been incorporated have reduced the incidence of cell flooding. The problem of cell reactant tube plugging and cell "ballooning" are being investigated. Design fixes now being evaluated show improvement in these areas.

Three prototype A fuel cell modules were delivered to NAA in December 1963. The initial test of 4 hours on load was successfully conducted by NAA personnel.

Table VI is an accumulation of test hours at Pratt and Whitney as of January 8, 1964.

TABLE VI.- ACCUMULATED TEST HOURS

Configuration	Test Hours	
	At Temp.	On Load
Single cells	Approximately 70,000	Approximately 35,000
6 cell stacks	7,849	5,141
31 cell stacks	6,355	3,189
Independent modules	8,157	3,891

Cryogenic Storage System.- The new titanium forgings for the hydrogen pressure vessels and the Inconel forging billet for the oxygen pressure vessels have been approved by NAA. Weld certification for the titanium vessels has also been completed. An additional machining source for hydrogen and oxygen pressure vessels has been established to increase hardware availability. Initial deliveries of machined forgings have been made by both machining vendors. Following initial failure of the Beech fan motor, heater concept, development of a redesigned unit has shown much improvement. A prototype oxygen unit was subjected to 10 thermal shocks and then run in liquid oxygen for 178 hours with 638 stops and starts without any malfunction. The decision by NAA as to whether the fan motor, heater, or the concentric sphere heater configuration will be incorporated will be made early in the next quarter. Preliminary thermal tests of the hydrogen tank have indicated that the minimum heat leak that can be obtained with the present insulation design is about 13 Btu/Hr. The specification requirement is 6.2 Btu/Hr. Two approaches are now being taken on this heat leak problem. Beech is building-up a tank using improved insulation and also negotiating with an insulation vendor to insulate Beech tanks. Test results will be available early in the next quarter.

A complete set of cryogenic tanks for NAA house spacecraft boilerplate 14 was delivered to NAA.

Communications Subsystem

The first breadboard model of the CM TV camera (using standard components) has been delivered to NAA. Future models will use "micro"-modules and standard components. The first model has a photocell light-level detector, whereas the future models will have a peak video detector for the automatic light control. This feature will allow light attenuation on the order of 300 to 1 without picture degradation. The first experimental model is scheduled to be completed by February 3, 1964.

For the CM TV camera, RCA will utilize integrated circuitry in lieu of the previously planned micro-modules. This will simplify packaging problems from a moisture environmental standpoint and should result in a price reduction.

At a meeting with NAA, it was pointed out that the present packaging weight for electronic equipment is 580 lbs. If the vertical coldplate concept were utilized, it is calculated that the packaging weight would be on the order of 407 lbs. NAA will submit a proposed study plan concerning the vertical coldplate concept as part of Block II consideration.

Operational restrictions and predicted performance degradation incurred by the present S-band transponder design, when operating with a Jet Propulsion Laboratory (JPL) S-band ground station, make certain changes in the spacecraft equipment design desirable. A major effort is underway to define the unified S-band system requirements and the test programs necessary to certify SC-ground compatibility. JPL and GSFC are cooperating with MSC in resolving the problem.

Present calculations indicate that the egress/regress hatch is the only area of the CM which will be out of the water under all sea state conditions which may be experienced. Studies are being made to determine whether a deployable type recovery antenna can be installed in this area.

Development of an S-band Klystron power amplifier has been initiated as a backup to the present S-band power amplifier which uses the Hughes Traveling Wave Tube. The Klystron tube development program at Litton

Industries is progressing in an orderly manner, with the first prototype model due to be delivered to Collins in January 1964.

The communications equipment being built by Collins Radio Corporation is complete through the first two engineering models. Prequalification and application tests are in progress on all the completed equipment.

The second revision of the Apollo Spacecraft/ground operation support system (GOSS) Communications Circuit Margin Report, NAA SID 62-14521, has been published.

The completion date for the Spacecraft GOSS Interface Test System (SGITS) facility in Building 6 at NAA has been rescheduled for March 1, 1964.

Service Propulsion Subsystem (SPS)

The Arnold-Engineering and Development Center (AEDC) conducted 23 altitude firings to evaluate facility modifications made to reduce test-cell blowback, increase facility performance, and obtain engine design data. Nine of these firings were conducted with all titanium nozzle extensions and three with columbium titanium. The last test was terminated prior to the programed shutdown due to buckling of the titanium material just below the columbium section. As a result, the extensions have been redesigned and forwarded to the AEDC for continued testing. Additional facility modifications have also been completed for reducing the test-cell blowback pressure. Tests with redesigned nozzle extensions are scheduled to begin on January 30, 1964. Action has been taken to insure that sufficient hardware will be available at the test site for completing the tests scheduled to end March 28, 1964.

Corrective action has been taken to eliminate the pressure spikes which have been occurring when the upstream solenoid valve of the helium regulator is opened. An antisurge device has been placed downstream of the primary regulator. Tests indicate that this modification has eliminated the pressure spike.

The heat exchanger has successfully completed the high pressure test and appears structurally adequate. The helium and propellant pressure Delta P evaluations have been completed and do not pose a problem at this time.

Two fuel, oxidizer and helium, flight-weight tanks have been acceptance tested and delivered.

Reaction Control Subsystem

The function of the reaction control subsystem (RCS) is to provide attitude control for the spacecraft. The CM and SM RCS engines are undergoing development testing to establish combustion performances and operational life. Qualification testing is scheduled to start in the 2nd and 3rd quarter 1964 for the SM and CM engines, respectively. Development testing on the propellant and pressurization system components is nearly complete, and design verification testing has been started on several components. Qualification of all components will be complete in the 4th quarter 1964. Breadboard systems testing for the CM and SM RCS using prequalified hardware will commence during the next report period.

Since the last reporting period, the new CM chambers incorporating a 90° oriented ablative material in lieu of macerated ablative material have been tested. Further testing is planned for the next reporting period, using a 45° oriented material.

An alternative throat insert has been successfully tested under steady state run conditions. This insert is a precharred ablative material in place of the original silicon carbide insert. This modification is to be tested under pulse mode operation during the next reporting period.

A series of tests is planned to determine the characteristics of a "soft seat" valve for the CM engine. The results of this series of tests are scheduled to be available during the next reporting period.

Solution of the chamber failure problems in the SM RCS engine have been accomplished. The "spider configuration" injector, wherein the oxidizer flow passages between the injector and valve consist of numerous tubes to eliminate overheating of oxidizer, has apparently eliminated the hot-phase burning problem. The "Ribbed" thrust chamber incorporating circumferential ribs in the chamber to withstand the ignition pressure spike has been tested. The injector-chamber combination will be tested during the next reporting period.

The bladder life problem has been solved by incorporating an "over-size" bladder. This change will utilize the SM oxidizer bladder in the SM fuel tank, the SM fuel bladder in the CM oxidizer tank, the CM oxidizer bladder in the CM fuel tank, and will require only one new bladder for the SM oxidizer tank. This solution to the problem is to allow more wrinkling and shrinkage of the bladder before it becomes too small for the tank. No change in tank delivery schedule is anticipated.

Launch Escape Subsystem

The launch escape subsystem (LES) provides the means of propelling the CM to a safe attitude and position in the event of a pad abort or suborbital abort. Three rocket motors (launch escape, tower jettison, and pitch control) comprise the LES in addition to the structural housing and a truss-type frame which provides attachment to the CM.

At the conclusion of the scheduled development testing on the launch escape motor, it was apparent that motor thrust was below minimum specification limits. This was further amplified by the boilerplate 6 flight test results which indicated a thrust level 8 percent lower than predicted. Analysis of the development test data indicated that the proper thrust output could be achieved by increasing the ratio of ground oxidizer/total propellant weight from 29 percent to 31 percent. Two motors were cast with a 31-percent oxidizer grind ratio, and these will be fired as preflight rating test motors to verify ballistic performance prior to beginning the qualification test program. Qualification testing is scheduled to begin the next reporting period.

Qualification testing of the pitch control motor will commence when a propellant formulation is finalized for the launch escape motor since common peopellant is used.

Vibration testing of the two tower jettison motors was completed, and a temperature rise was again evident at the high temperature (140° F) high g (±5g) input at a nominal 250-cps resonant frequency. No temperature rise was experienced at a moderate acceleration input (±3g) and no problems are foreseen with operational motors since these vibration conditions will not be encountered in actual motor use.

One of these vibration tested motors was fired satisfactorily and the other is being detained pending completion of pyrogen igniter tests with hot wire initiators. A problem presently exists with structural compatibility of the hot wire initiator/cartridge and the pyrogen pellet basket. Since no compatibility problem was experienced with exploding bridgewire (EBW) initiators, the initiator/cartridge output is being tailored to correspond to that of the EBW. At the conclusion of the satisfactory pyrogen tests with the modified initiator cartridges, the remaining tower jettison motor will be test fired. Qualification testing is scheduled to begin during the next reporting period. Supplemental tests on the escape tower attach points have been completed and the data are being analyzed. No problems have been encountered.

North American Aviation, Inc. proposed and was subsequently directed to implement a technique of escaping from the launch vehicle after the launch escape tower has been jettisoned. The system consists of a manually started automatic-solid-state-logic sequence. The same system will be utilized for normal separation except that the SPS engine will not be fired.

The mission sequencer emergency detection system voting logic is being implemented as a solid-state-two out of three voting devices.

The boilerplate 6 test which was conducted on November 7, 1963, had no apparent sequencer anomalies.

Research and Development Instrumentation Subsystem

NAA has requested that MSC provide a backup support for the development of heat shield transducers for AFRM 009. Accordingly, IESD has been given a work order to support AFRM 009 heat shield instrumentation requirements by providing a measurement system for temperature, char, ablation, and incident heat flux (in tested prototype form) along with qualification date and procurement sources to NAA by June 1, 1964.

Essentially all flight and spare hardware for boilerplates 12, 13, 15, and 23 have been delivered to NAA.

In-Flight Test Subsystem (IFTS)

The first delivery of a prototype IFTS to North American Aviation, Inc. is scheduled for June 1, 1964. This unit will support the boilerplate 14 operations.

Revision C, MC 901-0063C, IFTS procurement specification, has been released by North American with concurrence by MSC, NASA.

Pyrotechnics

Pyrotechnic Systems and Devices.- A study of an indexing system for the initiator connectors and the igniter cartridges was conducted for two reasons: (1) the installation points for the igniter cartridges of the launch escape and tower jettison motors being close, and (2) the interchangeability of cartridges having identical thread sizes. As a result of this study, a method of postmanufacture indexing of initiator connectors has been conceived and implemented to prevent connection of the wrong firing wires to any initiator. Further, design control has been established on threaded cartridges to assure that all are different.

Apollo Standard Initiator.- The static-electrical-discharge sensitivity problem, caused by close pin-to-case spacing, is expected to be solved during the next quarter. Part of the problem lay in the test setup, instrumentation, and controls wherein, instead of the application of 9,000 volts, transients as high as 20,000 volts were being applied.

This has been solved, and means of reducing the sensitivity are now being tested. This sensitivity problem is primarily one of safety in handling and installation, and adequate detailed techniques and procedures are being followed to assure personnel safety. The initiator is now to be used for ignition of the Recruit Motors on Little Joe II, marking another advance in the acceptance of the standard initiator concept.

Apollo Standard Detonator.- Procurement of new thin-walled detonators has been initiated. These detonators will also have an increased explosive charge to assure a detonation capability for all sizes of the linear shaped charge as well as the mild and confined detonating fuse. This device is a pacing item for all high explosive charge devices, such as the explosive bolt.

Launch Escape Tower – Command Module Separation System.- The dual mode explosive bolt will be used for both the upper and lower separation planes. The bolt is now in development; both internal and external charges have been sized. Below -30° F the internal charge produces an irregular fracture; however, since the environment will not be below 0° F, this margin of safety is considered to be adequate. Delivery of the first prototype hardware is expected about the end of March 1964.

Command-Service Module Separation System.- The linear shaped charges for severing the tension ties and the umbilical have been sized. A specification for the pyrotechnic circuit interrupter (dead face switch) to prevent shorting of critical electrical circuits has been issued.

SM-Adapter Separation System.- This system is being redesigned to make all cuts on splice plates, the upper being at the SM interface and the lower at the plane of the LEM attach points. The adapter segments will be rotated about hinge points at the lower plane and remain attached to the lower adapter section rather than being jettisoned. The umbilical between the SM and adapter will probably be cut by linear shaped charges (cf. CM-SM separation system).

Adapter – LEM Separation System.- The current tentative design concept consists of linear shaped charges to cut tension straps which hold the LEM to the adapter at the support points. The firing circuits will probably be routed through the CM–LEM carry-on umbilical.

Service Module Propellant Dispersal System.- A requirement has been established to disperse the propellant in the service propulsion system. There is no requirement to destruct the module structure or to disperse RCS propellants or cryogenic liquids. Several design concepts are being studied. Design criteria, to be established shortly, will dictate concept selection to a large extent.

Forward Heat Shield Separation System.- This system has been redesigned to accommodate the thermal expansion and contraction of the outer CM and heat shield structure and the dual mode separation of the tower from the CM. Test hardware has been fabricated and the thruster cartridge charge is being established.

Earth Landing System Components.- The problems of high mortar reaction loads and debris from the end closures of the mortar cartridges are nearly solved and the new charges will be fixed early next quarter. The new S/C prototype cartridges will be used on boilerplate 12. The drogue and main cluster disconnects are currently under redesign concept study; final selection and design are awaiting a decision on the means of attaching the parachutes to the CM structure. The old drogue disconnect, with an interim thin-walled detonator, will be used on boilerplate 12; no main cluster disconnect will be used.

Launch Escape System Components.- Two types of igniter cartridges for the rocket motors are required because of the configuration of the pyrogen units; one cartridge will be used for the launch escape and pitch control motors and the other for the tower jettison motor.

CM Reaction Control System Components.- Two normally closed explosive valves are being procured, one for the helium pressurization system (two used) and one for the propellant jettison system (ten used). The helium valve will be operated by the standard initiator; tests will be run to assure an adequate margin of safety. The propellant valve will be operated by a pressure cartridge. Procurement specifications for both valves have been issued, and the possibility of using these valves in the LEM RCS system will be considered.

A review of the firing circuitry in the propellant-jettison-system explosive valves disclosed several unacceptable single-failure modes. Since only one initiator can be used in each valve, the dual bridge wires in the initiator can be used to solve this problem by connecting bridge A-B to one pyro battery and bridge C-D to the other.

Training and Training Equipment

NAA and MSC investigations into the problem of providing crew comfort in a one "g" gravitational field resulted in the decision that the simulated CM will be oriented with the X-axis vertical. All special comfort provisions will be in the leg support of the couch.

An Apollo Part Task Trainer design review was held December 3 to 5, 1963. The briefings covered design criteria, design approach to various subsystems of the trainer, and status of the program.

North American Aviation received and initiated evaluation of proposals for the computer subsystem of the Apollo Part Task Trainer. These proposals are for analog computer equipment, interface equipment, and integration of the computer subsystem. The digital computer has been ordered and is the same computer model used in the Apollo and Gemini mission simulators.

The visual simulation system for the Apollo mission simulator was reviewed on January 28 and 29, 1964. The design of the infinity image system is 90 percent complete. The star field generation design is 90 percent complete, the rendezvous image generation system design is 60 percent complete, and the mission effects projector design 15 percent complete. Librascope, Inc. has been awarded a contract for the sextant simulation and has begun error analysis on its preliminary design.

LUNAR EXCURSION MODULE (LEM)

Guidance and Navigation System

NASA Headquarters approved the MSC LEM Guidance and Navigation procurement plan on October 18, 1963. The contractors were the Massachusetts Institute of Technology (Instrumentation Laboratory), Raytheon, Kollsman, and A. C. Spark Plug.

The LEM guidance and navigation will be similar to the Block II CM guidance and navigation. Definition of CM Block II guidance and navigation indicates a probable weight decrease of 18 pounds each in both the computer and inertial measurement unit.

Ryan Electronics was selected by RCA to develop the LEM landing radar. RCA has a subcontract from the Grumman Aircraft Engineering Corporation for both the landing and rendezvous radars. The rendezvous radar is an RCA in-house effort.

Stabilization and Control Subsystem (SCS)

Subsystem Development Status.- The LEM SCS hardware end-items have been identified as follows:

Control subsystem (9 end items):

1. Attitude and translation control assembly (ATCA)
2. Guidance coupler assembly (GCA)
3. Descent engine control assembly (DECA)
4. (Includes gimbal actuators)
5. Inflight monitor assembly (IFMA)
6. Rate gyro assembly (RGA)
7. Attitude controller (AC)
8. Translation and thrust controller (TTC)
9. Attitude display and control panel

Backup guidance subsystem (3 end items):

1. Attitude reference assembly (ARA)
2. Backup programmer assembly (BPA)
3. Control panel (CP)

The current estimated total system weight is 117.5 pounds.

GAEC is procuring the subsystems by assemblies on competitive bid. The ATCA, GCA, DECA and IFMA will be procured from Radio Corporation of America. The RGA will be procured from Kearflott Corporation.

The following are the approved Design Concepts:

a. LEM back-up guidance attitude reference was established as a 4-gimbal platform. The procurement specification was completed but not released. Redirection is in process on a "strapdown" ARA.

b. Common usage CSM-SCS hardware in the LEM under evaluation are jet drivers, demodulators, rotational hand controller, and flight director attitude indicator. The CSM translational thrust hand controller has been determined unsuitable for LEM. The CSM rotational controller has been directed to be a common usage item for LEM.

c. Non-redundant descent engine gimbal actuation (providing a weight saving) was approved by ASPO. The actuator will be a slow speed actuator providing only a trim function.

d. A "No in-flight maintenance" concept was adopted.

Allied development accomplishments are as follows:

a. The RGA procurement specification was completed by GAEC.

b. A preliminary draft of the SCS requirements specification was completed by ASPO

c. An ASPO study of the adequacy of a vertical-line window reticle for the selection of a landing site is complete. A more detailed GAEC study is in progress.

d. An ASPO study of a degraded attitude-reference system in the LEM abort system is complete.

e. A functional description of the LEM backup guidance requirements was completed by GAEC.

Major design changes are as follows:

a. Active dual redundancy for rate gyros
b. Strapped-down Attitude Reference System

Landing Gear Subsystem

At the November 1963 MSC Mechanical Systems Meeting, MSC approved changing the landing gear configuration from the 180-inch radius tripod gear to a 160- inch radius cantilevered-type gear. The 160-inch radius gear stability characteristics are in some respects superior to the 180-inch tripod gear, and all cases investigated met the work statement and design model requirements. Other improved features are: LEM stowed height reduced 9 inches; 20-inch vertical stroke instead of 40 inches; gear is better protected from lunar surface protuberances; slight reduction in gear heating problem; better capability of taking eccentric loading on the landing pads; provisions for the up-lock to be simplified; and lighter in weight.

An analytical estimate of the crushing loads of preliminary engine skirt designs and their effects on landing stability is underway. Initial estimates indicate that average crushing loads in excess of 1,500 pounds will affect stability under some landing conditions. Load tests of scaled engine skirts will be performed to augment analytical programs as the configuration of the engine skirt is firmed.

LEM landing stability limits are also being examined with respect to variations in those parameters of the current lunar surface model which affect stability. This program will support scale model and full-scale drop tests, and will provide requirements for the lunar reconnaissance programs.

Structural Subsystem

As described in the Summary of this report, the LEM ascent stage configuration was changed from the four tank design to a two tank design, resulting in a lower weight, lower overall center of gravity, improved propellant feed system, and direct structural attachment to the descent stage.

The LEM structure, which consists of two separate stages, the descent and ascent stages, is shown in figure 4. Figure 5 depicts the descent stage which is the unmanned portion of the LEM while figure 6 shows the ascent stage which is the manned portion of the LEM.

Crew Equipment Subsystem

It has been established that two complete flight control stations are not required for the LEM. In lieu of the categorical requirements, the following basic ground rules for the design of the crew station flight control facilities were given the contractor (within the framework of apportioned reliability requirements for crew safety and mission success):

a. The LEM shall be provisioned such that hover to touchdown in the descent trajectory may be flown manually by the astronaut.

b. No single failure in the controls and displays shall cause an abort.

c. Unknowns associated with lighting conditions and/or dust caused by rocket exhaust impingement on the surface may impose a requirement to land under VFR/IFR conditions as a joint effort between crew members.

Accordingly, dual flight controls and windows, gross attitude, attitude error and vehicle rates information are required. Other displays such as altitude, altitude rate (range, range rate) et cetera must be readable from either station or dual. Subsequent simulations and analyses of crew tasks, flight control techniques, and mission will provide a final definitive list of duplicated or shared displays.

A concerted effort was initiated to insure a maximum degree of commonality between LEM and CM controls and displays. Guidelines have been established which govern the general approach to controls and displays, including principles of layout, switch orientation, and nomenclature conventions. The first of a series of meetings between the contractors for this express purpose has been conducted.

Phase II of an MSC Lunar Landing Site Selection Study has been completed. The objective of the study was to arrive at an early indication of the crew's capability to select an acceptable landing site under lighting conditions simulating earthshine (varying degrees) over completely unfamiliar terrain approximating the lunar surface. A helicopter, equipped to simulate LEM window configuration, flying proposed LEM descent trajectories was the test mechanism. Data and results obtained during the study are being analyzed and a technical report published.

The contractor has completed a comprehensive study to determine the feasibility of an electro-luminescence (EL) lighting scheme, and the present system consists of EL with supplementary incadescent for panel lighting with backup flood lights. The present EL color is white and the brightness varies from 0 to 0.5 foot lamberts. The selection of 6 volts as opposed to 28 volts as a power source for incandescent bulbs is dependent on the results of vibration tests now being conducted. The M-1 mock-up is now, and prior to M-5 will be, used as a tool for evaluating flood light installations, EL panels, silhouette lighting techniques, and window reflections. M-5 will function as a complete lighting mock-up. For external lighting, studies are not complete.

A support and restraint system redesign has been accomplished which should eliminate the objectionable features noted during the M-1 Mock-up Review. The basic concept of a standing crewman, however, has not been changed. The present system consists of a torso support cantilevered from the front bulkhead with harness attach points laterally positioned in each hip area. The support also accommodates the arm rests and hand controllers. The harness is similar in many respects to a parachute harness but modified and refined according to the requirements unique to this application. The system has not been mocked-up yet with any degree of sophistication, but the design is complete for TM-1 and should be available for initial evaluation in February 1964.

The complete crew station design, including control/display panels, support/restraint, equipment arrangement and stowage provisions, et cetera, has been completed for TM-1 which is the test model for comprehensive evaluation of crew provisions. The vehicle will be available for review in March 1964.

Environmental Control Subsystem (ECS)

A major effort during this period has been directed toward completing the optimization studies for weight and power reduction. The more significant of these studies are discussed in the following paragraphs.

Carbon Dioxide (CO_2) Absorber/Suit Fan Location. - Tests and studies indicate that the suit fan should be located upstream of the CO_2 absorber. In this configuration the suit fan will require less power. Preliminary studies of the efficiency of the portable life support system (PLSS) lithium hydroxide cartridge indicate that a larger cartridge may be more suitable for the LEM ECS.

Cabin Fan. - Preliminary results indicate a weight reduction on the order of 19 pounds can be obtained by using two small fans rather than one large fan. During a majority of the mission only one fan would be required to operate. Also under examination is the possibility of allowing condensation to occur in the cabin heat exchanger. This would allow considerable reduction in heat exchanger weight and fan power. A moisture removal system for operation on the lunar surface is being investigated. Condensation during zero "G" conditions is undesirable and it is believed that the system can be designed to avoid this occurrence except for the orbital contingency case.

Space Radiator. - Results of these studies indicate that a definite weight savings can be achieved if the mission profile is restricted to a night landing. No such restriction is acceptable at this time. In-house studies are currently underway to investigate the space radiator for an unrestricted landing site and time. These studies will include: full radiator usage, sequenced radiator-water supplement usage, and surface geometry. The feasibility of integrating an ECS radiator with the fuel cell cooling circuit is also being investigated.

The present schematic provides a glycol to oxygen regenerative heat exchanger for suit inlet temperature control. GAEC was directed to investigate a warm-gas bypass concept that would fulfill the same requirement. Preliminary tests performed on the centrifugal water separator indicated that the concept is not feasible because of the reduced efficiency obtained under varying gas flows.

GAEC was directed to provide a redundant glycol loop for critical electronic equipment. This coolant loop will use one of the pumps in the present glycol pump package, a separate plate fin water boiler, and will use the water management system for an accumulator. This system will be designed such that it can be removed if later tests indicate that sufficient thermal inertia is present to allow a safe return to the CM after loss of the glycol loop.

Electrical Power Subsystem (EPS)

Power Distribution.- GAEC completed the inverter study and recommended a decentralized inverter system. ASPO has withheld full approval of the system pending completion of a reliability evaluation of the brushless dc motors, which would be used in the decentralized system. Completion of the reliability evaluation is planned by January 29, 1964.

GAEC has completed evaluation of the auxiliary battery vendor proposals. The battery contract award is dependent upon fuel cell configuration selection, which will determine battery size.

Cryogenic Storage.- GAEC completed evaluation of proposals for cryogenic tankage during this reporting period. AiResearch was selected as the potential supplier, and negotiations were begun on December 2, 1963. Negotiations have been delayed due to the fuel cell configuration question. The tank size and number of hydrogen tanks depend on whether two fuel cells and a battery or three fuel cells are used in the power generation system (PGS). Present schedules call for negotiations to be complete and a purchase order to be issued to AiResearch by February 1964.

Fuel Cells.- The results of the weight reliability study, mentioned in Quarterly Status Report No. 5, were presented to MSC. The configuration recommendation was not approved by MSC due to the lack of cost and schedule impact information. On December 20, 1963, MSC requested additional information and study from GAEC.

Currently, the PGS consists of 3 - 900 watt fuel cells. MSC outlined four possible configurations to be studied to resolve the PGS problem. These configurations were: (a) 3 fuel cells (900 and 1,125 watt), (b) 2 fuel cells (900 and 1,125 watt), (c) 2 fuel cells, optimized for LEM requirements, and (d) 2 fuel cells, optimized to combined CSM-LEM requirements. The reason for studying the 1,125 watt fuel cells is based on information that the current design can be uprated from 900 to 1,125 without resizing. The preceding study in (d) has been requested to assess what penalty would be involved in sizing the new LEM configuration to be compatible with CSM requirements for potential backup to current CSM fuel cells.

A task force from GAEC was sent to Pratt and Whitney to assist in expediting the studies required to determine the optimum configurations when assessed with the latest power profile information and requirement. Results are to be presented to MSC on March 12, 1964, in order to select a final LEM PGS configuration. In the interim, design of the proposed fuel cell assembly (FCA), 900 watt size, has progressed and is considered to be approximately 90 percent complete.

The facility at Pratt and Whitney for development of the FCA is approximately 20 percent complete. Beneficial occupancy is scheduled for April 1964. GAEC test facilities at Peconic, Long Island, New York, are being built. A gas test facility to be used for testing fuel cells with gaseous reactants is essentially complete, but test equipment has not been installed. Work is underway on two cryogenic test bays.

Communications Subsystem

A decision was made by the ASPO to provide GAEC with the LEM television camera as government furnished equipment (GFE). The MSC Instrumentation and Electronic Systems Division, E and D, has accepted the responsibility for development of this camera. Procurement will be started by late January 1964. Negotiations for the communications subsystem were started between GAEC and RCA, and are expected to be completed by February 1, 1964.

Propulsion Subsystem

General. - Grumman Aircraft Engineering Corporation completed the release of procurement specifications for both the ascent and descent propellant and pressurization components during the month of December 1963. Issuance of purchase orders for these components is scheduled for the next quarter. Slosh testing of the ascent and descent tankage is being delayed by late subcontractor delivery of the plexiglas tanks and by several mechanical and instrumentation problems discovered during checkout of the GAEC slosh rig.

Descent. - Allison Division of General Motors Corporation was chosen as the subcontractor for the descent stage propellant tanks, and a limited go-ahead was issued by GAEC on December 3, 1963. The tanks will be fabricated from titanium material.

Throttling tests over the full throttling range were conducted at Rocketdyne on a workhorse engine. A simulated life cycle test was conducted on a workhorse engine, including a 515-second continuous firing and a 750-second total firing time. During October and November 1963, testing was suspended for a 5-week period due to design problems on a weld joint in the injector body, which allowed propellant leakage to occur. Testing was resumed after the workhorse injectors were modified, and a redesign was made for hardware not yet fabricated. As a result of this and other more minor delays, an approximate 8-week behind-schedule status was evident. Rocketdyne has initiated Block I and Block II prototype engines to reduce this behind schedule status. This approach allows testing of prototype thrust chambers and a closed loop thrust control system prior to the availability of certain other prototype components.

Space Technology Laboratory (STL) has completed firings of the 1-inch throat engine for ablative materials evaluation. A total of 85 tests was made. The three most promising materials are being tested on a 4.75-inch throat engine for further evaluation. The first throttling tests were accomplished on November 1, 1963, and drawings for the workhorse ablative chamber engine were released November 15, 1963. Due to a problem of low performance of the injector, the first workhorse ablative chamber engine tests were delayed about two months, and are now scheduled for late January 1964. STL has continued to stockpile hardware and will attempt to recover their schedule by an increased test frequency.

Major activities planned for the next quarter include initiation of cold flow tests on the heavyweight rig at GAEC. STL plans to accomplish their first full scale ablative chamber tests and full range injector throttling tests, and the first engine firing in their vertical engine test stand at the new test site at San Juan Capistrano. They also plan to start release of the prototype engine drawings. Rocketdyne plans to release both Block I and Block II prototype engine designs, and to accomplish performance, off-design, and combustion stability tests.

Ascent. - Bell has stated that the specification value for the specific impulse of the ascent engine cannot be achieved. The predicted specific impulse value will be low by approximately four points.

Bell has decided to continue into the phase "B" screening with all three chamber designs, AVCO, Hitco and Tapco. The Tapco chamber with the "hard" throat appears promising. Bell will purchase eight complete Tapco chambers for the phase "B" screening.

GAEC has adopted the two propellant tank configurations for the ascent stage and has changed the tank material from aluminum to titanium.

The ascent heavyweight rigs are approximately 5 weeks behind schedule due to the propellant tank configuration change.

Reaction Control Subsystem

During the past quarter the primary effort was in the area of completing the procurement specifications and construction of the HR-1, HR-2, and cold-flow test facility. The completion of the component specification release is presently scheduled for February 1, 1964, and the purchase orders are to be placed during the forthcoming quarter.

The helium system checkout rig (HR-1) is expected to be completed in the middle of January 1964, and the evaluation of the pressurization system concepts will be initiated at that time.

The completion of the cold-flow test facility and the RCS checkout rig (HR-2) is being delayed by approximately one month due to changes in the live runs, caused by the redesign of the ascent propulsion system tankage.

The major effort on the part of the subcontractor, the Marquardt Corporation, was in the area of the thrust chambers and cluster assemblies. The development status of the common use RCS engine is reported under the SM reaction control system.

Approximately 200 firings were performed at the Marquardt Corporation on the "workhorse" cluster assembly. An explosion in the injector of the "vertical up" quad during the sea-level firing of that quad interrupted the test program and an investigation as to the cause of explosion is currently underway.

Plans for the next quarter include completion of purchase orders for the system components, HR-1 and HR-2 testing at GAEC. Also, analytical studies pertaining to the thermal problems associated with the LEM engine clusters and hydrodynamic effects of the propellant feed system are expected to be completed at GAEC.

The Marquardt Corporation will continue with the cluster firing tests and also is expected to finalize the cluster support design.

Radar Subsystem

Ryan Aeronautical, San Diego, California, was selected by RCA as the landing radar vendor.

The rendezvous radar design has started at RCA, and power and weight trade-off studies are under way.

A contract was signed between RCA and GAEC for the rendezvous and landing radars.

Negotiations have also been completed between RCA and GAEC for the radars.

Operational Instrumentation Subsystem

Negotiations were completed between GAEC and Radiation, Inc. for the PCM telemetry and timing equipment. Radiation, Inc. has started preliminary design.

MSC requested that GAEC cease all efforts associated with the data storage equipment pending re-evaluation of the data storage requirements. GAEC is studying the feasibility of transmission of the LEM telemetry low-bit rate data to the C/SM for recording if the data storage equipment was not required.

Flight Research and Development Instrumentation Subsystem

Flight research and development instrumentation is being procured upon an approved measurement requirements list for LEM-1. Initial procurements are for type qualification tests.

The basic flight research and development instrumentation package will consist of five FM/FM telemetry packages.

Scientific Instrumentation Subsystem

The Space Environment Group attached to ASTD let a study contract to Texas Instruments Company on September 30, 1963. This contract is to be completed in 10 months and will investigate areas of scientific interest and instrumentation requirements for manned lunar exploration.

NASA Headquarters has initiated an effort to poll the scientific community for candidate experiments on the lunar surface. The plans for experiment selection and implementation have not been finalized.

Training And Training Equipment

GAEC completed evaluation of proposals on the external visual display equipment subsystem of the LEM Mission Training Simulator. GAEC selected Farrand Optical Company as the recommended source, this selection was approved by MSC, and GAEC has initiated contract negotiations.

GAEC completed preparation of preliminary specifications and vendor requirements documents for the LEM Mission Training Simulator. Release of the Release for Quotation (RFQ) is scheduled for February 3, 1964.

ADAPTER

The configuration of the S-IVB adapter at the end of this reporting period has been established as a truncated cone 336 inches in length. The LEM support points are at spacecraft station $X_A = 584.7$. The configuration freeze date has been set as February 1, 1964, to allow design completion by July 7, 1964, and to support delivery of the first article (boilerplate 27).

SPACE SUIT

The second prototype Apollo space suit was received on October 21, 1963, and evaluated at North American Aviation in the CM on October 24 and 25, 1963. Mobility while pressurized was generally inadequate. Astronaut J. Young, wearing a pressurized suit with a mock-up portable life support system, encountered considerable difficulty in attempting an egress through the CM hatch.

The Hamilton Standard-International Latex Corporation mock-up suit with a new shoulder and elbow joint was tested in the NAA couch/CM display arrangement on the Johnsville, Pennsylvania, U. S. Navy centrifuge. The vertical position of the forearms in the pressurized suit overlapped the arm rest about 6 inches. The vertical position of the forearms in the unpressurized suit overlapped the arm rest $1\frac{1}{2}$ inches. An elbow restraint and a forearm restraint alleviated these conditions for the unpressurized condition, however, satisfactory controller operation was never obtained with the pressurized suit.

The second portable life support system was received from Hamilton Standard, December 13, 1963, for test and evaluation. Mobility capabilities of pressurized suited subjects in the Apollo phase B suit with portable life support system were conducted at 1/6g in the Air Force KC-135 aircraft. Results of the tests which included film coverage, indicated that further and more extensive testing is needed and will be scheduled for early January 1964.

SPACECRAFT SYSTEMS ENGINEERING

FLIGHT TECHNOLOGY

Aerodynamics

During the past quarter, the decision was made to proceed with the "tower flap dual mode" launch escape vehicle (LEV) design as the prime design approach. Effort is continuing within MSC on the design of an alternative LEV configuration using deployable canards.

During the reporting period, the launch escape system (LES) pad abort performance and stability were demonstrated in the flight of boilerplate 6 at WSMR. Range and altitude were essentially as predicted prior to the flight and well beyond the minimum requirements at apogee. The LEV was aerodynamically stable during the abort up to tower jettison, although the dynamic stability was somewhat less than predicted. Further correlation of the test data with regard to aerodynamic characteristics is continuing.

The following wind tunnel programs were performed during the subject period:

FS-2 FS-3	Static stability tests of the tower flap post abort configuration at Ames Unitary and Arnold Engineering Development Center
FD-6	Dynamic stability tests of the tower flap post abort configurations at Ames 12-foot Tunnel
PSTL-2	Static and dynamic pressure distribution on the spacecraft during launch on the Saturn 5 vehicle
LEM/LJ II-	Static stability of the LEM/Little Joe II configuration in Langley's 8-foot transonic tunnel

Results of the FD-6 test have indicated that the tower flap and clean CM are dynamically unstable for Mach numbers up to 0.8. The instability of the tower flap is sufficient to tumble the CM and tower when only one RCS is operative. This will result in moving the dual mode changeover point from 30,000 feet to at least 50,000 feet. Some change in the sequencer timing may also be required. Analyses of the dynamic stability of the tower flap and the clean CM will be continued during the next quarter.

Little Joe II/LEM configuration was tested with 50 square-foot fins and found to have a negative static margin beyond the control capability of the launch vehicle. Wind tunnel tests are presently being conducted with larger fins of 75 square-foot area and 100 square-foot area to alleviate this control problem.

Ablation Material Thermal Performance

The ablation heat shield has been redesigned to incorporate the following changes:

(a) Revised heating rates

(b) Decreased density of the 5026 ablator

(c) Improved thermal analysis computer program

(d) Increase in the number of heat shield design points from 62 to 258.

The ablator density has been reduced by changing the manufacturing technique of filling the honeycomb from tamping to insertion with a high pressure gun. The new thermal analysis program incorporates a number of changes to the physical ablation model including variable sublimation temperature as a function of input heating rate. As a result of these changes, the ablator weight, reported by AVCO, has increased 194 pounds to a total of 1,547 pounds including bond material. NAA is reviewing the design in an effort to reduce the weight.

A test program was initiated at AVCO, Langley Research Center, and Ames Research Center to further explore the influence of high aerodynamic shear on the ablative material. Similarly, two dimensional wedge models are being tested in the three facilities to identify better the influence of test conditions on the performance of the ablator and to identify the proper method of extrapolation of the test data to flight conditions. During the next quarter, the results of this test program will be compared and their implications on the Scout flight test and Apollo heat shield design will be determined.

All four Scout nose caps have been delivered to Langley. It is now estimated that the first launch of a Scout nose cap with the current Apollo ablative material will occur during the second quarter of 1964.

Aerodynamic Heat Transfer

MSC has been exploring the recent experimental and analytical information regarding possible increases in radiative heating due to the contribution of the ultraviolet portion of the spectrum. The potential effect on Apollo radiative heating is an increase by a factor of two to three. Further study will be done during the next quarter on the subject prior to recommending the incorporation of this factor in the Apollo design heating rates. The effect on the heat shield design will probably be small because radiative heating represents a small percentage of the total heat load during reentry.

Natural Environment

Both NAA and GAEC are conducting investigations of the influence of various meteoroid protection criteria on the spacecraft designs. These studies are based on the latest meteoroid flux model and the Summer's penetration equation. The studies include a detailed failure effects investigation of meteoroid penetration, the effect of including and excluding the shower component of the meteoroid flux, and the weight increase in each of the modules caused by various crew safety and mission success probability requirements up to 0.9999. The results of these two studies will be presented to MSC during the forthcoming quarter and a specific design criteria will be selected.

The negotiations between NAA and the General Motors Corporation for a meteoroid impact simulation test program have been completed. The contract has been reviewed by the Resident Office of ASPO and it is expected that the program will begin before February 1, 1964.

Radiation Dose

Computations of the dose at the center of the CM utilizing a 183 region spherical shell model code have been made at MSC. The dose delivered to the skin of the whole body when a phantom is in place is approximately 72 rad. This computation is based on a design flux of 2.4×10^9 protons/cm^2, corresponding to a flare with a 1-percent probability of occurrence. The dose at the blood forming organs and the eyes as computed for this flux is 7.1 and 40 rad, respectively.

It can be noted that these dose values are considerably below the nominal dose limits with the exception of the eye dose which can be reduced to the specified limits with a minimum amount of shielding. However, these computations do not include the dose due to the passage through the radiation belts.

The dose numbers quoted herein are considered to be preliminary and are presented only to give an order of magnitude indication of the status as of the date of this report. Considerable effort is being expended at MSC and at NAA to obtain more accurate dose values and to investigate various methods of dose reduction. It is expected that during the next quarter, more accurate dose values will be available from the NAA and the MSC computer codes and that more up-to-date radiation belt data will be available.

Engineering Simulation

The Farrand Optical Co., Inc. has been chosen to provide the visual display systems for the LEM simulation and training programs. Delivery of the two systems is scheduled for early 1965.

A GAEC Docking Simulation (IA-2) was cancelled because of deletion of the extendible probe docking system, and to allow extension of the Rendezvous Simulation IIA through January 1964.

The LEM Abort Simulation III being conducted at Ling-Temco-Vought has been delayed due to difficulty in computer mechanization. It is expected to begin operation by January 27, 1964, and operate through February 1964.

Evaluators 1 and 2 are currently operating at NAA. Evaluator 1 is conducting a simulation of the boost and abort phases of flight. Evaluator 2 simulation is concerned with coast, midcourse maneuvering, and SM abort phases of flight.

SYSTEMS INTEGRATION

ASPO is currently preparing a study recommending In-Flight maintenance requirements for the Block II CSM. This study has precipitated the following additional requirements:

(a) Ground rules must be developed determining whether or not the data (not voice) up and down link capabilities are mission success criteria.

(b) A joint contractor study must determine whether packaging techniques common to both LEM and CM are feasible.

(c) If common packaging is not the best approach, packaging techniques that best satisfy the individual CM and LEM constraints must be developed.

NAA expects to release in preliminary form that portion of the "Apollo Signal Definition Document" which defines GSE - Spacecraft subsystem interfaces by mid-February 1964.

GAEC has received direction to prepare a "Signal Definition Document" for LEM similar to the NAA document mentioned above. No schedules concerning this document have yet been defined. It is expected that MIT will provide a similar document for the guidance and navigation system.

NAA is providing Functional-Time-Flow Diagrams for all boilerplate 14 equipment and equipment interfaces. NAA expects to provide this type of drawing for all airframes.

It is expected that GAEC and MIT will be required to provide similar drawings for their respective equipment and equipment interfaces.

In support of revised plans for Apollo flight testing, requirement for a mission programer (the equipment needed aboard Apollo to accomplish unmanned flights) was certified. The ASPO requirements of the mission programer can be summarized as follows:

(a) Accomplishment of normal ON-OFF functions

(b) Provision for failure - abort situations

(c) Automatic alinement of stabilization references, for flights longer than about one day

(d) Flexible design to accommodate mission complexity and changes.

A study of the possible applicability of the Gemini crewman simulator to the Apollo needs has been initiated. Preliminary results indicate that the Gemini device will not be usable for Apollo because:

(a) The Gemini unmanned mission is about 20 minutes in length; Apollo plans are for flights lasting hours or days.

(b) Important differences exist between Gemini and Apollo in the means of separating the spacecraft from the boosters, in deorbiting procedure, and in the detailed operation of the subsystems.

The CSM Electrical Power Load Analysis, based on the 14-day Lunar Landing Mission, indicates the following electrical energy requirements:

(a)	Fuel cell energy	578.4	KWHR
(b)	Entry and landing	1060.5	W-H
(c)	Post landing	904.8	W-H

GAEC is in the process of preparing an electrical power system (EPS) Design Load Analysis based on the LEM-EPS Critical Design Mission. This load analysis will be used as a basis for design of the LEM EPS.

ASPO has initiated arrangements with NAA and GAEC to establish a power control program. The program will include definition of types of Normal and Emergency Electrical Power Load Analysis; Subsystem Electrical Energy Apportionment; Methods of Electrical Power Reporting and Review; and Control of Electrical Energy Growth.

DESIGN INTEGRATION

Docking Interface

The ASPO has transmitted the Docking Interface Ground Rules and Performance and Design Criteria to NAA and GAEC to serve as guidelines in the development of the docking interface. The major ground rules are summarized as follows:

(a) There are tow modes of docking operations; the primary mode will result in a structural connection suitable for crew transfer and mission operations. The emergency mode will result in free space extravehicular crew and payload transfer.

(b) The CSM is assigned an active role in translunar docking and both the CSM and LEM will be capable of assuming the active role in the lunar orbit docking operation.

(c) An unaided crewman must be capable of executing the docking maneuver and crew transfer for either the primary or emergency mode.

(d) There are two modes of crew transfer in the docked configuration; the primary mode is intramodular with an open faceplate space suit. The emregency mode is extravehicular with a pressurized space suit and portable life support system. In addition, the spacecraft design will accommodate free space extravehicular crew transfer for emergency docking operations.

(e) The docking interface systems will not compromise other subsystem operations or increase the complexity of emergency mission operations.

Apollo Spacecraft Weight

Table VII shows the control, design goal, and current weight status and changes from previously reported data. The CM and SM weights increased 120 pounds and 280 pounds respectively. The transearth propellant requirement increased 245 pounds as a result. LEM ascent and

TABLE VII. - APOLLO SPACECRAFT WEIGHT STATUS

Lunar Orbit Rendezvous Mission

	Control Weight, lb		Design Goal, lb		Current Weight, lb		Change From Last Report, lb		Remarks
A. Command Module (including crew)		9,500		8,500		9,770		+120	
B. Service Module		50,400		45,850		49,491		-85	ΔV margin = 10%
Inert	10,500		9,500		9,960		+280		
Usable [a]SPS propellant - Translunar (ΔV_1 = 3,883 fps)	27,700		25,370		29,250		-610		
Usable SPS propellant - Transearth (ΔV_2 = 4,801 fps)	12,200		10,980		12,035		+245		[b]SPS I_{sp} = 313.0 sec
Total	50,400		45,850		49,491		-85		
C. Lunar Excursion Module (w/o crew)		26,700		25,000		30,465		-1,950	ΔV margin = 10%
Descent stage inert	3,640		3,550		3,485		-150		[c]DSC I_{sp} = 305.0 sec
Usable descent propellant (ΔV_3 = 7,827 fps)	14,900		13,950		16,905		-1,060		
Ascent stage inert	3,970		3,675		5,000		-375		[d]ASC I_{sp} = 303.0 sec
Usable ascent propellant (ΔV_4 = 7,079 fps)	4,190		3,825		5,095		-365		
Total	26,700		25,000		30,465		-1,950		
D. Adapter		3,400		3,000		3,400		0	
E. Total Spacecraft Injection Weight		90,000		82,350		94,880		-1,915	
Launch Escape System Weight		6,600		6,400		7,215		+565	
Total Launch Weight		96,600		88,750		102,095		-1,350	

[a]SPS = Service Propulsion System

[b]I_{sp} = Specific Impulse

[c]DSC = Descent Stage of Lunar Excursion Module

[d]ACS = Ascent Stage of Lunar Excursion Module

NOTE: Lunar excursion module propellant tank capacity has been increased to carry sufficient propellant to meet the required ΔV with the current LEM inert weight.

descent stage inert weights are reduced 375 pounds and 150 pounds, respectively, as a result of the emphasis on weight reduction. Ascent and decent propellant requirements are decreased 365 pounds and 1,060 pounds each as a result. The reduction of LEM weight results in a decrease of 610 pounds of translunar propellant.

Command Module.- Changes to the CM include structural changes for forward heat shield release system redesign, forward pitch motor protection, increased center section ablation material, addition of a second drogue parachute, and docking provisions. The major weight increase is due to the docking provisions.

Service Module.- The majority of the SM weight increase results from the addition of the rendezvous radar installation. Weight of the supercritical hydrogen storage tanks is increased due to additional wall thickness required as a result of a test tank failure.

Launch Escape System.- Additional structure, electrical system requirements, separation provisions, and insulation have increased the LES weight 135 pounds. A heat shield protective cover increased the weight 175 pounds. The addition of 255 pounds of ballast is required to move the combined CM/LES center of gravity forward due to aerodynamic stability requirements.

Lunar Excursion Module.- The LEM weight change resulted primarily from reduction of structural weight associated with meteoroid protection, reduction of wire gage and insulation thickness and reduction of the number of sensors and associated wiring. However, the propellant requirements based on the resultant stage inert weights exceed the tank capacities. The tanks have therefore been resized to provide sufficient capacities and the weights adjusted to these values shown in table VII.

An extensive program to reduce LEM weight has been initiated at GAEC and is beginning to produce results. Emphasis on LEM weight reduction will continue. Due to identical weight problems, similar programs are required for the remaining modules. An integrated weight control program for the complete spacecraft is therefore being prepared for immediate implementation at all contractors.

CREW INTEGRATION

The centrifuge test program was conducted between October 25 and December 20, 1963, to determine the CM crew support, suit, and control display acceptability under acceleration loads. The tests confirmed earlier interface problems between the suit and the couch; that is, suit-elbow area expansion beyond the couch arm support and restriction of downward vision by the lower portion of the helmet faceplate. While the crew restraint system was found acceptable, the chest buckle for the harness created problems both in pressure on the chest under acceleration and in lack of accessibility. Subpanels 5, 9, and 16 of the main display console proved inadequate due to lack of visibility and difficulty of access due to obstruction by the hand controllers and the clearance required by the wrist rings of the pressure suit glove assembly. No crew tolerance or serious performance difficulties were experienced under the acceleration profiles of interest and the displays subpanels 2 and 4 were adequately visibile. The Manned Spacecraft Center is preparing a working paper on results of the program including pilot's comments. A separate analysis of the data is being prepared by North American Aviation, Inc. The Massachusetts Institute of Technology has already completed memoranda reports on a brief test pertaining to the guidance and navigation display and keyboard (subpanel 14.)

Each subsystem, its functional logic, and the associated controls and displays have been reviewed on a schedule which completes a review of all systems by January 29, 1964. The results of this control display review, the centrifuge program, and several changes to systems will require a rework of the main display console. It is expected that all changes will be consolidated not later than February 15, 1964.

The Preliminary Integrated Apollo Flight Crew Task Analysis, 14-Day Lunar Landing Mission, NAA SID 64-73, was published December 30, 1963, and is being reviewed by MSC elements.

TEST PROGRAM PLANNING

On November 6, 1963, Apollo contractors, NAA, GAEC, and MIT, were directed to form an Integrated Contractor Team for the purpose of conducting a review of the overall Apollo Test Program. A set of ground rules and guidelines for planning purposes was provided by Apollo Spacecraft Program Manager, and the Chief of the Systems Engineering Division was designated as the ASPO point of contact for guidance and coordination. Ground rules and guidelines were revised in some respects as the result of later ASPO/Integrated Contractor Team discussions.

A first cut test program was completed by November 25, 1963, and a preliminary Saturn/Apollo Flight Program on December 4, 1963 (Figs. 7-10).

Additional backup information relative to the proposed major ground and flight tests has also been received from the contractor team. A contractor presentation will be made to ASPO/MSC on January 3, 1964.

RELIABILITY

A reliability and flight worthiness assessment for boilerplate 6 was prepared for the use of the "Mission Readiness Review Committee." Although the assessment did not result in any hardware or design changes, it served the purpose of focusing attention upon marginal or potential problem areas and pointed out the need for more detailed and comprehensive information to support the flight worthiness assessments for future missions. Similar assessments are now underway for boilerplate 12 and boilerplate 13.

A critical review and evaluation of MIT/IL Reliability Program Plan (R349, Rev. A) were completed. This evaluation was based upon the requirements of NASA Reliability Publication 250-1, Reliability Program Provisions for Space System Contractors. A meeting was held with the Manager of Reliability and Quality Assurance at MIT/IL on December 17, 1963, for a detailed discussion of the recommended changes in the Reliability Program Plan. MIT has agreed to incorporate all of the recommended changes in a revised Reliability Program Plan which is planned for publication on January 31, 1964.

An MSC Reliability Assessment study of the LES for the Apollo spacecraft was completed. As a result of this study, specific recommendations were made to North American Aviation, Inc., covering areas of possible reliability improvement. The results of this independent assessment generally substantiated the reliability predictions prepared by NAA/S and ID.

Detailed plans have been completed for an integrated Apollo Data Center. This data center, using high speed computers for the storage and retrieval of various types of reliability, quality, and related engineering information, is needed because of the accelerated time schedules of the Apollo program, the large number of contractors, and the enormous volume of information. It is expected that the automated data center will enable the storage and instantaneous retrieval of various types of information such as trouble, failure and corrective action data, parts qualification status, operating time/or cycles on limited life items, parts application information, mission success, and crew safety reliability assessments, test results, parts qualification status, parts application information, et cetera. Moreover, the use of this technique for obtaining fast and frequent program visibility is expected to yield information with respect to supplier performance, potential reliability and quality problem areas, and reliability and quality trends. The detailed requirements for input data from the major contractors are specifically delineated in a document entitled

"Contractor Information Control Center Requirements." This document was sent to MIT/IL, NAA/S and ID, and GAEC for review and comment. A series of meetings to discuss this program has been and is being held with each of the above contractors. Present plans contemplate the initiation of the Electronic Data Processing of failure and corrective action reports at the MSC Computer Center, no later than February 1964. All of the available failure and corrective action data generated in the Mercury program is currently stored on magnetic tape in the data center and is available for immediate dissemination upon request. This information should prove valuable to the Apollo program in pointing up potential reliability or quality problem areas, since it contains data with respect to MSC "common usage" parts and because many of the major subcontractors are the same for the Apollo program as was the case in the Mercury program (for example, AiResearch for the ECS system; Collins Radio for communications, et cetera.)

A complete listing of all Mercury failures and corrective action has been furnished to NAA/S and ID, MIT/IL, and GAEC, and GD/Convair, San Diego, as well as each of the ASPO offices.

QUALITY ASSURANCE

A detailed review and evaluation of the MIT/IL Quality Program Plan were completed and recommendations for revision and improvement of this document have been forwarded to MIT. MIT will submit a revised Quality Program Plan in March 1964.

A draft of a proposed consolidated and standardized Acceptance Data Package for deliverable end-items was completed and is ready for submission to the three major contractors for implementation.

The Government Inspection Agency Inspection Plan for LEM prepared by BUWEPS, Bethpage, N.Y., has been completed, reviewed, and approved.

A review was made of the Aerojet General Proposal PSD-63154 for the procurement of eleven additional ALGOL rocket engines for the Little Joe II program for the adequacy of the quality assurance requirements. The work statement for this document was revised to reflect the additional quality requirements.

Three were with boilerplate 1 and five were with boilerplate 2. Tests were conducted on land and water with the land test numbers being 55 through 59, and the water test numbers being 60 through 61. The land

tests were conducted at roll conditions of 0° through 180° and also to verify the crushable-edge tumbling concept. The crew compartment struts were bottomed and severely damaged on three land drops.

Boilerplate 25

During the month of October 1963, this vehicle was used operationally to evaluate the Apollo retrieval rig on the motor vessel 'Retriever'. Several runs were made, both in the Gulf of Mexico and in Galveston Bay. An evaluation was made of the mock-up of the NAA suggested recovery bale and the spacecraft was picked up in several attitudes, including one with a 30° cant. The large bale could be utilized satisfactorily, although there were some disadvantages. This Apollo boilerplate was used to determine the operational effectiveness of a davit retrieval rig on board the motor vessel 'Retriever' in the Gulf and in the Bay. The MSC part of this evaluation has been completed and a demonstration has been conducted for the DOD and Navy representatives. It is planned that the davit retrieval rig and boilerplate 25 will be sent to the Norfolk Naval Base within the first quarter of 1964 for further evaluation aboard destroyer type vessels. The problems associated with retrieval by carriers, tankers, and ARS type vessels will also be investigated.

AFRM 008

Status and Data Acquisition System (DAS).- NAA is implementing a hardline concept for accommodating all research and development measurement requirements (research and development measurements are defined as those not a part of the flight and PACE checkout complement) associated with the AFRM 008 environmental proof test (EPT). PCM and flight qualification measurements will be handled according to normal S/C operation. PACE carry-on checkout equipment will remain on board for initial unmanned tests.

Measurements.- NAA is attempting to reduce the present quantity of measurements reflected in the November 6, 1963, AFRM 008 Measurement Requirements List (SID63-508-1). NAA is using the later part of February 1964 as a target date for release of what is hoped to be a firm or frozen measurement list.

MSC PACE Station: Plans have been formalized for the calendar timing/installation of the Houston, Texas, PACE station with the installation and checkout of GSE. GE and NAA are working toward their implementation.

SPACECRAFT TEST

GROUND TEST ARTICLES

Test Fixture F-2

Manufacturing of Test Fixture F-2 (service propulsion subsystem) was completed during the last reporting period (July-September 1963). The test fixture was shipped directly from NAA's Los Angeles Division on October 9, 1963, and arrived at White Sands Missile Range (WSMR) on October 14, 1963. Following its receiving inspection, the fixture was placed into storage in Building 1540, WSMR, until the construction of Test Stand I at the Propulsion System Development Facility (PSDF) was completed and could accept the test article. Test Fixture F-2 was removed from storage and placed on Test Stand I on December 27, 1963.

The Data Acquisition System was delivered to the PSDF from Beckman Instruments, Inc., on December 12, 1963. The system has been installed and is scheduled to complete its acceptance testing by February 1, 1964.

During the last reporting period, the initial firing of F-2 was slipped until March 6, 1964, due to slippage of F-2's GSE. Utilizing the current estimated delivery dates for the GSE, the earliest firing utilizing F-2 will not be until late in the second quarter of 1964.

Airframe 001 (Service Module Only)

Airframe 001 SM was removed from the assembly jig and installed into the pick-up jig on November 1, 1963. On December 20, 1963, the SM was moved from the pick-up jig in Building 6 and transferred into Building 290. Completion of the basic structure will continue in Building 290 along with wiring harness installation, plumbing installation, and subsystem installation. However, based on present known delivery dates of the SM's subsystem, manufacturing will not be completed until mid-August 1964. This represents a slip of 5 months within manufacturing when compared to the dates presented in Master Development Schedule (MDS) 7.

NAA has been requested to present their recovery plan to MSC in January 1964, to return the SM within scope of MDS 7. However, it is probable that the GSE for Airframe 001 SM will be the major pacing item to support any schedule.

Boilerplates 1 and 2

In this quarter, a total of eight impact tests were conducted.

MSC Facility/AFRM 008 GSE: Plans have also been formalized for the installation/integration of the MSC PACE station with the Space Environment Facility (SEF) and the AFRM 008 GSE.

MSC Facility Activation Plan: NAA is in the process of finalizing their proposed activation plan for the MSC SEF. This plan is being closely coordinated with the E and D Directorate's Structures and Mechanics Division (S and MD).

Man Rating and Safety Requirements.- A NAA/NASA committee has recently been established for the purpose of determining the requirements for and definition of the man-rating and safety of the EPT T/V chamber. GAEC will be invited to participate.

Logistics.- NAA is preparing a spares requirement plan in support of AFRM 008 testing at MSC. This plan should be available for ASPO review in February 1964.

AFRM 008 General Test Plan.- NAA is continuing work on updating the initially proposed 7-Run Test Plan. This task included simplifying, combining, and further definitizing the originally proposed test plan. This will also include the best currently-known man-rating and safety aspects of environmental chamber operation.

CSM/LTA Ground Test Plan.- NAA has not completed their study and proposed test requirements for the ground test anticipated at NAA and MSC. The recent NAA effort on the proposed Apollo S/C Development Plan, Document AP63-86, limited their effort and prevented their scheduled presentation to ASPO on December 15, 1963. This information was required to permit proper long-range planning with MSC Facility Personnel.

Plans.- 1. To propose a survey of existing large man-rated operational environmental facilities in the U.S. for purposes of obtaining information on anticipated as opposed to actual effort of initial checkout, operation, and man-rating of chambers. These data are to be used as a "yardstick" for updating the MSC chamber checkout plans.

2. To accelerate the effort to firm-up measurement requirements list, definitize instrumentation installation criteria and complete release of all instrumentation procurement.

3. To accelerate the effort to release the CSM/LTA Ground Test Plan.

4. To evolve an optimized PACE station design for the MSC Environmental Facility.

Boilerplate 14

Status.- Structural design was completed October 1, 1963, as scheduled. Systems design release was not completed December 31, 1963. Necessary design changes and corrections, noted during production planning and initial fabrication, have resulted in rescheduling completion of engineering to February 1, 1964.

Completion of the structural assembly was delayed because of the above engineering changes and is now scheduled for mid-January 1964 as opposed to mid-November 1963. This is expected to result in a mid-April 1964 completion of final installation and checkout. Completion was previously scheduled for mid-February 1964. The start of complete systems tests in June 1964 instead of April 1964 is expected. The electrical power system (EPS) tests will be first, followed by tests on the environmental control system (ECS).

Plans.- NAA will be requested to submit, for ASPO review and information, a detailed plan of proposed testing with a weekly increment of scheduling.

Boilerplate 27/LTA-2

Boilerplate 27 - Status.- Design has been completed and the LES, CM, and SM are on schedule for a May 1, 1964, delivery to MSFC.

Problems.- Recent engineering changes (length changed to 336 in. from 345 in.) on the S-IVB (LEM) adapter result in a schedule delay in completion of the LEM adapter.

Plans.- NAA and ASPO are negotiating a S-IVB adapter delivery schedule compatible with the MSFC test requirements.

LTA-2 - Status.- The basic design has been completed; however, LTA-2 as presently under contract does not meet MSFC requirements regarding ballast capability.

Problem.- MSFC requires a means to "off load" propellant (ballast) on LTA-2 during Saturn I-B and V testing.

Plans.- ASPO is processing a CCA to implement the necessary changes.

AFRM 006

Status.- The CM structure design was released January 1963. System installation design release is on schedule for mid-February 1964. The SM structure design was released in July 1963 and the system installation design is on schedule for MDS-7.

Manufacturing problems have been encountered, causing a delay in completion of the CM structure sub-assemblies. Correction of the tooling has been completed and rework of the honeycomb bonding discrepancies (voids in face sheet to core bond) are in process. The contractor is endeavoring to regain schedule. The system component deliveries are generally on schedule, and oxygen and water/water-glycol valves will pace completion of the ECS. Late procurement of purchased and fabricated parts will contribute a two weeks delay on final delivery of the communication and instrumentation (C and I) system. Design changes on the RCS and heat shield have resulted in later estimates of delivery completions. Estimated date for the last RCS delivery now is July 1964 instead of April 1964 and September 1964 instead of July 1964 on the heat shield.

Revised manufacturing planning is in process at NAA and efforts are being made to regain the MDS-7 schedule position before completion of system(s) installation and checkout scheduled for October 1964.

FLIGHT TEST ARTICLES

Boilerplate 12

Boilerplate 12 was transferred from manufacturing to the ATO area on October 18, 1963. The individual systems tests were accelerated during December by initiating a three-shift operation, in an attempt to provide a minimum slip to the MDS-7 delivery date. Previously, schedule slippage occurred due to underestimating manufacturing time, removal of aerodynamic strakes, and working off design engineering inspection (DEI) items. The integrated systems tests are expected to commence on January 25, 1964. The SM will be shipped to WSMR on or about February 1, 1964 and the CM will be scheduled for shipment about February 6, 1964. The Little Joe II launch vehicle DEI was conducted on November 14, 1963, and it is expected to arrive at WSMR on February 7, 1964, indicating a slight delay due to the design and installation of thrust termination system (TTS). The TTS may be utilized instead of the command destruct system design which was flown on the qualification test vehicle. In working a 5-day week scheduled at WSMR, the estimated launch date is April 15, 1964.

Boilerplate 13

Boilerplate 13 was transferred to the Apollo Test and Operations (ATO) checkout area to undergo factory acceptance testing on November 28, 1963. Checkout was delayed due to non-availability of GSE required for performing the Integrated Systems Test, and problems encountered with GSE validation when it finally arrived. The Integrated Systems Test is now scheduled to begin on January 27, 1964, with field delivery on February 5, 1964. This is approximately 4 weeks behind delivery date per MDS-7.

Boilerplate 15

Boilerplate 15 has completed manufacturing. A NAA in-house development engineering inspection is scheduled for January 8, 1964. The NASA development engineering inspection is scheduled for January 30, 1964. The spacecraft has been stacked for a fit check of all modules, and returned to the final assembly area to undergo power on checks. Several delays were encountered due to "cannibalizing" the vehicle for instrumentation components which were needed to facilitate the boilerplate 13 checkout. This was possible due to the similarity of the two vehicles. It is anticipated that this instrumentation will be replaced by new instrumentation without causing a schedule slip.

Boilerplate 16

The SM, insert and adapter, and related GSE have completed manufacturing and are scheduled to be delivered to MSFC by the middle of January 1964. This date will be approximately one month behind MDS-7, but 3 weeks in advance of a redefined MSFC need date which essentially relieved NAA of the MDS-7 date.

NAA has been directed to reconfigure the LES for boilerplates 16 and 26 to lighten the payload weight. The inert propellant and nozzles will be removed from the launch escape motor and the pitch control motor will be deleted.

Boilerplate 19

During this quarter, 4 boilerplate tests were conducted at El Centro, California. One test was in support of boilerplate 6 abort test, and two were in support of boilerplate 12 flight conditions and one which was the first dual simultaneous deployed drogues on a boilerplate. All tests were successful.

Boilerplate 22

Manufacturing of the assembly started in late December 1963. Procurement fabrication and delivery of the hockey stick longerons was the pacing item during this time. The forward bulkhead assembly was held up for approximately 2 weeks due to the lateness of the longerons arrival in manufacturing. This delay will be absorbed by a three-shift operation in place of the planned two shift basis. All structural problems have now been resolved and since no major changes are envisioned at this time, the scheduled completion is anticipated to be on time. The manufacture of the wiring harness at Slauson is now the pacing item with approximately 2 weeks negative slack. This slack is due to late engineering releases. The engineering area is getting maximum support to resolve the slack.

Logistics is in the planning stage for programing GSE. The program GSE for boilerplate 22 will have first usage items as well as time shared items with other boilerplates.

Simultaneously GSE WSMR facility requirements have been exercised to meet the new requirements for the handling of RCS propellants peculiar to boilerplate 22. Review of the new Downey facilities is in progress and boilerplate 22 will be the first boilerplate to go through the new Building 290 assembly and checkout areas. Contractor planning is intensive in order to minimize the problems that will be encountered in operating the checkout facility.

Boilerplate 23

During this reporting period boilerplate 23, which has the same configuration as boilerplate 12, has neared completion in manufacturing. MDS-7 indicated manufacturing completion on January 3, 1964, and completion is not expected until January 23, 1964. A six weeks delay is expected on the launch schedule due in part to the fact that boilerplate 12 must clear ATO before the testing of boilerplate 23 can commence.

A test plan was presented by NAA to the ASPO in mid-October with the intention of full availability of GSE by modifying boilerplate 6 GSE after boilerplate 6 launch and by time sharing of boilerplate 12 GSE. A decision was reached in December 1963 by NAA and was presented to the ASPO that boilerplate 6 GSE MODS were impractical on certain equipments due to the long time requirements for modifications. A new program was then prepared utilizing the NAA single shift effort and a minimum amount of SMD to accomplish all OTP's up to, but not including, stacking and integrated systems checkout. The plan is still under review by ASPO.

Airframe 002

AFRM 002 CM and SM structural drawings are now complete. This includes both the inner and outer structures. Systems design and configuration is in accord with MDS-7. AFRM 002 is about 2 weeks into manufacturing. Bits and pieces are being manufactured, but no major assemblies are being assembled.

Airframe 010

AFRM 010 command module and service module basic structure drawings were completed during this reporting period.

Airframe 009

Manufacturing.- The crew compartment inner structure is approximately 80 percent complete. The inner aft side wall is awaiting welding of the bulkhead assembly. AFRM 006 which was pacing AFRM 009 through tooling is now out of the jigs so that AFRM 009 faces no tool problems. NAA reports that AFRM 009 is approximately 9 weeks behind MDS-7 because of the tooling problems with AFRM 006; however, they hope to recover 4 weeks in the bonding sequence.

Heat Shield Instrumentation.- In November, ASPO authorized a work order for IESD to conduct the development of certain types of sensors concurrently with NAA in an attempt to assure that at least one sensor of each type, that is, char, ablation, and incident heat flux, was available to support AFRM 009 schedule. To date, IESD has not manned this effort to the level they proposed as being required to meet the schedule. Consequently, the effort appears to be behind schedule and may not be completed in time to support the AFRM 009 schedule.

LAUNCH VEHICLE DEVELOPMENT

LITTLE JOE II

Convair has completed manufacture on all of the four Little Joe II vehicles without control systems. The DEI for the second and third vehicles was held simultaneously on November 14, 1963. The second vehicle will be shipped to WSMR the first week in February 1964 to support the initial spacecraft flight of boilerplate 12. The third vehicle will be in storage as a backup to this flight. The fourth vehicle has also been placed in storage until required to support the spacecraft flight tests. The airframes and fins for the first two vehicles with control systems (vehicles 5 and 6) have been completed. Installation of instrumentation is in work on schedule, and vehicles will be placed in storage without rocket motor ignition harnesses since the exact test conditions and numbers of motors required are not known.

Convair has been authorized to design, develop, and qualify a dual thrust termination system for the boilerplate 12 flight in lieu of using WSMR destruct system hardware.

Convair has been given contractual go ahead for two additional follow on vehicles with control systems for spacecraft flight tests (vehicles 7 and 8).

A contract will be negotiated with Aerojet in February 1964 for 12 additional rocket motors with canted nozzles to partially support the four vehicles with control systems.

Convair is preparing to start integrated control system tests in which control system hardware will replace simulated components on the analog computor. The reaction control module has been completed by Walter Kidde for vibration tests with motors thrusting. Tests are approximately 6 weeks behind schedule but is not expected to affect scheduled flight tests.

Configuration of the Little Joe II launch vehicle is shown in figure 11.

OPERATIONS PLANNING

GRUMMAN AIRCRAFT ENGINEERING CORPORATION (GAEC) MISSION

Planning Study

The Apollo Spacecraft Program Office has initiated a detailed study of the Spacecraft functional requirements associated with the entire lunar landing mission. The study will integrate the lunar mission planning activities carried out by MSC, NAA, MIT, and GAEC. Direction is provided by a Study Direction Group located at GAEC and chaired by that organization. The Group is composed of representatives from all participating organizations. In addition to the major participants, cooperation and support are being provided by Bellcomm, GE, MSFC, KSC, and GSFC.

The study is to include examination of the currently assumed mission ground rules and criteria to determine their desirability and consistency between contractors and the generation of an envelope of design missions including both nominal and contingency considerations. GAEC has broken the mission down into phases and assigned each phase to a small study group. These groups listed the operational flexibility requirements and the problem areas they were able to identify under each phase. This material was examined by the Study Direction Group for additions and deletions, and preliminary task assignments to the participating organizations were made. Efforts to revise the Apollo Lunar Landing Mission Design Plan have been discontinued in favor of supporting the GAEC Mission Planning Study.

Specific outputs expected from the study include:

1. Reference Mission - A detailed description of a single, nominal mission to be used for a variety of purposes including height and reliability reporting.

2. Operational Flexibility Requirements - Variations from the Reference Mission which the spacecraft must be able to perform, including alternate missions and aborts.

3. Subsystem Critical Missions - Descriptions of the most difficult combinations of 1 and 2 above from the viewpoint of each spacecraft subsystem. To be used to derive subsystem functional specifications.

Apollo Systems Specification M-DM 8000.001

Comments have been received from each of the ASPO systems offices on the design objectives contained in the Apollo System Specification. These comments have been discussed informally with the Office of Manned Space Flight (OMSF) and Bellcomm. The majority of these design objectives will require additional study before they can be properly disposed. These studies are being initiated.

Revisions to sections 4.4, 4.5, and 4.8 were proposed by Bellcomm. Sections 4.5 and 4.8 (Spacecraft Communications) have been reviewed by MSC and our comments discussed with Bellcomm. Bellcomm is now preparing another revision of these sections. Section 4.4 (Guidance) has been distributed for comments.

A list of 26 apparent discrepancies between the system specification and current spacecraft design has been compiled. GE support is being utilized to study each discrepancy and recommend an appropriate resolution.

A copy of the Apollo System Description has been received from NASA, Daytona, for proofreading. Review of this draft has been completed and comments were forwarded to OMSF for publication. Distribution is expected about the first of February 1964.

CSM and LEM Incremental Velocity (ΔV) Budget

The ΔV budget was revised by MSC during this quarter to associate all margin allowances with specific items in the budget rather than an across-the-board 10 percent margin, and to remove any surplus from the ΔV budget in keeping with the necessity to remove all unnecessary weight from the spacecraft.

The revised budget was reviewed by ASPO management and submitted to

OMSF for approval.

Major changes include substitution of a Hohmann transfer for the equi-period LEM descent and reducing the minimum duration of the trans-earth trajectory (after lunar orbit) from 60 to 85 hours.

A requirement for a SM destruct system has been accepted by MSC. Development of design criteria and direction to the Apollo contractor to implement system development have not been completed.

AMR Range Safety has been requested to give MSC their data showing how temperature inversion characteristics in the Cape Kennedy area might restrict the times when a SM containing toxic propellants may be launched. These data are expected early in February 1964.

The mission time line to be used for the LEM electrical energy profile was revised. The effect of the revision is to provide a 48-hour LEM capability beginning with separation in lunar orbit rather than including the pre-separation checkouts in the 48 hours as was previously done. This requirement is now compatible with the Apollo System Specification.

PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

Grumman Aircraft Engineering Corporation completed coverage by PERT on all subsystems, manufacturing and acceptance, ground tests, and flight operations line items. The GSE line item was partially covered. Systems engineering, training, quality, reliability, logistics, system simulation, and program planning and management are the line items reported on the 533 report (Financial Management Report) which have not been covered with PERT. GSE and systems engineering are planned for completion by the end of the next quarter. A determination of the extent of coverage on the remaining line items will be made during the next quarter.

During the reporting period, a major review of existing PERT networks was conducted by North American Aviation, Inc. and MSC Program Control and Engineering personnel. Every network was reviewed and necessary revisions made to make the networks reflect the program (MDS-7). The total integrated PERT system became operational with the December 17, 1963, update. Although there are still some few items to be completed and some PERT mechanics problems to be worked out, this system is operational.

ACCEPTANCE CHECKOUT EQUIPMENT (ACE)

Management control of the ACE-Spacecraft Project Office was shifted from Cape Kennedy to MSC-Houston. All procurement, funding, and program control will be from Houston, Texas. The technical day to day contact with the contractors is the responsibility of the Electronic Ground Support Equipment Division at Florida Operations.

The project office reviewed and approved all GE bid packages for subcontracts so that GE can proceed with all required procurement as part of the GE task.

General Electric Company submitted a cost proposal for the two NAA ACE-Spacecraft Ground Stations, exclusive of the GFE. The Government is furnishing the computing system, peripherals, and the decommutation equipment. Contract for the decommutation equipment was placed with Radiation, Inc., while the contract for the computing system and peripheral equipment was placed with Control Data Corporation (CDC).

Technical activities were concentrated on defining the North American stations. The block diagram for the North American ACE-S/C stations was approved on October 10,1963 (Rev. A December 5, 1963). The Interface Control Documents between GE and NAA were prepared and signed by all interested parties on December 20, 1963. These documents define all the operational interfaces between the two contractors.

The actual design of the station has been completed, and all applicable system and component specifications have been approved. As part of the design, the facilities criteria at NAA were submitted to NAA for implementation.

Special studies by GE have been initiated in the area of reliability so as to assure the stations meet the operational requirements.

The development of the experimental station at the Florida Operations is progressing. The digital test monitoring system (DTMS) was sent through final tests at NAA during the last week of December and was delivered to the experimental station at AMR. Final acceptance tests were completed on the interim alphanumeric display system during the week of October 7, 1963. Acceptance tests on the digital test command system breadboard were completed the last week of December 1963. This DTCS was the first system delivered to the experimental station by NAA. It was delivered in October 1963. Acceptance tests on the data insertion equipment (CUE-START) were completed the last week of December. This equipment was delivered to the experimental station by CDC and represents the interface between the computers and the control consoles.

Acceptance tests on the digital transmission and verification converters were completed on July 29, 1963. During this series of tests, data were successfully transmitted over 12 miles of AMR provided A2A data links, thus proving the capability of the remote control by ACE-S/C. The magnetic tape recorder/computer time decoder and search unit for the experimental station was received and installed in December, thus making the computing complex complete except for the final computer.

A preliminary copy of the Computer Programing Plan was completed. This plan lays out the total programing effort of GE and defines the digital programs to be generated. Digital programs have been generated for the test assembly, the uplink (allowing commands to be transmitted to the spacecraft), and the acceptance program for the 160G. In addition, the conventional programs pertaining to input-output exercising the peripheral equipment and the standard internal routines, submitted by CDC, have been reviewed and incorporated in the library of programs now available.

GROUND SUPPORT EQUIPMENT PROGRAM (GSE)

COMMAND AND SERVICE MODULES

The lifting ring on H14-042, hoist beam SM and S/C adapter, failed under proof load tests at NAA's Tulsa Facility. The Tulsa Laboratory report indicated improper welding techniques. A GSE item of this type which is being utilized at MSFC has been red-tagged pending either replacement or X-raying. NAA is correcting the faulty welding procedure and will replace the unit at MSFC with a corrected unit.

Review of the NAA cryogenic BME by MSC Florida Operations personnel indicates that this NAA equipment is a duplicate of the Gemini GSE. NAA has, as a result, been verbally requested to obtain proposals from AiResearch, supplier of the Gemini units.

Lewis Research Center has agreed to the allocation of $25,000 requested by this office for cryogenic research with the National Bureau of Standards. Studies will be made of the purity degradation of liquid hydrogen, liquid oxygen, and liquid nitrogen during transfer and servicing operations. Other tests may be conducted, depending on funding and equipment availability, which will add to existing knowledge of purity degradation during storage and other processes.

A meeting at Rocketdyne to discuss possible use of the Gemini propulsion checkout unit resulted in a decision by MSC not to use the equipment. Modifications required to make the unit suitable for Apollo use are extensive enough to preclude any cost savings, and it is also doubtful if schedules could be met.

The detailed requirements of MSC-E-1, Environmental Design Specification, were discussed with NAA. It was agreed that the equipment would either have to be designed to be used in areas of acoustics and vibration, or protection would have to be provided as a portion of the equipment. Other agreements reached were (1) MSFC drawing 10 MO 1071 would apply for explosion proofing, and (2) unqualified parts were to be identified and presented to NASA for a waiver.

NASA requirements for GSE PERT were formulated and presented to NAA for implementation into networks presently being formed.

NAA GSE end item specifications were reviewed for format and content, and were found to be unsatisfactory. NAA has been advised to use the outline in DOD Standardization Manual M-200A in preparing future end item specifications.

The NAA GSE required for bench tests of the Service Propulsion Subsystem and Reaction Control Subsystem at Florida Operations was reviewed and found to be inadequate. NAA was given GSE requirements for Florida Operations bench testing and requested to develop the equipment to satisfy bench test requirements.

During a review of the NAA Spacecraft Instrumentation Test Equipment (SITE) capabilities, it was determined that SITE could replace the in-flight test system (IFTS) BME at the Houston Environmental Test Facility. The SITE unit is scheduled to arrive at Houston during March 1965.

LUNAR EXCURSION MODULE

The first LEM GSE Flow Charts, used to define GSE requirements, were submitted and reviewed. The flow charts did not functionally relate the stated GSE requirements to hardware operations, and failed to show facility interfaces required for the GSE. Detail comments and NASA requirements were discussed with GAEC, after which GAEC was directed to revise and update the charts.

The latest PERT report includes approximately 80 GSE items. The GAEC in-house schedule evaluation has delayed submittal of additional PERT reports. It is anticipated that a report including 200 GSE items will be submitted during January 1964.

The NASA LEM GSE Plan which contained guidelines for PERT, environmental design criteria, environmental tests, common and concurrent use of GSE, and traceability has been deleted. Ground rules established by the document have been implemented, thereby negating the requirements for the document.

The present concept for propellant loading GSE incorporates an accuracy of 0.5 percent. This loading tolerance creates a weight problem for the spacecraft. GAEC has proposed a propellant loading system with an accuracy of 0.25 percent. ASPO is conducting a trade-off study to determine the feasibility of implementing the GAEC system or continuing with the present NAA system. The possibility of including an accurate on-board propellant measuring device is also being considered.

The GAEC investigation of NAA GSE for applicability on the LEM vehicle has progressed to the point of identifying 53 common use items. The coordination problems, NAA delivery schedules, and NAA data availability have dictated reassessment of the common use program by MSC management. It is expected that the final GSE common use list and plans for implementing the common use program will be firm by the end of January 1964.

FACILITIES

The status of the uncompleted industrial facilities at Downey, California, is as follows:

System integration and checkout construction	85 percent complete
Space system development facility	
Main building construction	65 percent complete
RCS construction	98 percent complete

WSMR-PSDF

Test complex 1 for SM	98 percent complete
Test complex 2 for SM	85 percent complete
Control center	98 percent complete
NAA preparation building	82 percent complete
Administration area	90 percent complete

Test stands for LEM, GAEC preparation building, and NASA common use labs have been designed. Construction is awaiting release of funds.

PUBLICATIONS RELEASED

NORTH AMERICAN AVIATION, INC.
CONTRACT NAS 9-150

Report no.	Subject	Report date
SID 62-109	Test	Sept. 30, 1963
SID 63-1204	Apollo Maintenance Procedures	Sept. 23, 1963
SID 63-1150	Attitude Rules and Criteria for LEM	Aug. 20, 1963
SID 62-435	Familiarization Manual	Sept. 30, 1963
SID 62-822-6	Monthly Failure Summary for August	Sept. 10, 1963
SID 63-1216	Drogue Parachute Release Failure	Sept. 19, 1963
SID 63-511-2	Apollo Measurements Requirements	Oct. 10, 1963
SID 62-99-20	Weight and Balance Report for Sept.	Oct. 1, 1963
SID 62-300-17	Monthly Progress Report for Sept.	Oct. 1, 1963
SID 62-417	GSE Planning and Requirements List	Oct. 1, 1963
SID 62-162	Apollo Training Plan	Nov. 1, 1963
SID 63-21-10	Monthly Quality Status Report for Sept.	Oct. 10, 1963
SID 63-214	Apollo Description Manual	Oct. 25, 1963
SID 63-1229	End Item Test Plan for BP 13	Oct. 1, 1963
SID 63-1286	Umbilical Connectors for BP 12, 22, and 23	Oct. 25, 1963
SID 62-822-7	Monthly Failure Summary for Sept.	Oct. 20, 1963
SID 62-99-21	Weight and Balance Report for Oct.	Nov. 1, 1963
SID 62-300-18	Monthly Progress Report for Oct.	Nov. 1, 1963
SID 63-1366	Pretest Report	Oct. 1963
SID 63-688	Heat Transfer and Pressure Tests	Oct. 1963

Report no.	Subject	Report date
SID 63-1035	Test Report	Oct. 1963
SID 63-1027	Pretest Report	Nov. 1963
SID 62-822-8	Monthly Failure Summary for Oct.	Nov. 10, 1963
SID 63-1196	Apollo Description Manual	Oct. 31, 1963
SID 63-21-11	Monthly Quality Status Report for Oct.	Nov. 10, 1963
SID 63-911	Test Report	Nov. 1963
SID 63-1000	Apollo Manpower Application Report	Nov. 1963
SID 62-99-22	Weight and Balance Report for Nov.	Dec. 1, 1963
SID 62-557-7	Quarterly Reliability Status Report	Oct. 31, 1963
SID 62-102	Manufacturing Plan	Dec. 1, 1963
SID 62-417	GSE Planning and Requirements	Nov. 1, 1963
SID 63-1442	Apollo Description Manual	Nov. 30, 1963
SID 62-300-19	Monthly Progress Report for Nov.	Dec. 1, 1963
SID 63-509-3	Measurement Requirements AFRM 009	Oct. 1, 1963
SID 63-568	Apollo Measurements Requirements	Nov. 8, 1963
SID 63-143-5	Actual Weight and Balance Report BP 2	Nov. 22, 1963
SID 63-1466	Description Manual	Dec. 15, 1963
SID 63-21-12	Monthly Quality Report for Nov.	Dec. 10, 1963
SID 62-99-23	Weight and Balance Report for Dec.	Jan. 1, 1963
SID 62-109	Test Plan	Dec. 30, 1963
SID 62-417	GSE Planning and Requirements	Dec. 1, 1963
SID 63-1000	Manpower Application Report	Dec. 1963
SID 63-1464	Test Report	Dec. 1963

Report no.	Subject	Report date
SID 63-508-1	C/M Measurement Requirements	Nov. 6, 1963
SID 63-1320	AFRM 007 Handling Operational Flow Sequence	Nov. 1, 1963

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CONTRACT NAS 9-153

E-1142	Systems Status Report	Oct. 15, 1963
E-1378	Monthly Technical Progress Report	May 1963
E-1388	Summary of Error Propagation	Aug. 1963
E-1353	Horizon Photometer and Parking Orbit Report	May 1963
E-1386	Report on Clear Resins	Aug. 1963
	Qualification Status List	Oct. 11, 1963
R-408	Design Concepts of Guidance Computer	June 1963
E-1410	Monthly Technical Progress Report	July 1963
63-234C	Quality Status Report	Sept. 1963
	Qualification Status List	Oct. 25, 1963
E-1142	Systems Status Report	Nov. 15, 1963
	Qualification Status List	Nov. 21, 1963
	Qualification Status List	Dec. 6, 1963
E-1425	Comparison of Readout Resolutions	Sept. 1963
	Qualification Status List	Dec. 20, 1963
E-1445	Monthly Technical Progress Report	Aug. 1963
E-1142	Systems Status Report	Dec. 15, 1963

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GRUMMAN AIRCRAFT ENGINEERING CORP.
CONTRACT NAS 9-1100

Report no.	Subject	Report date
LPR-550-100	Monthly Failure Summary for August	Sept. 9, 1963
LED-360-6	Study for Solar Flare Warning System	Oct. 5, 1963
LED-560-3	Presimulation Report	Aug. 5, 1963
LPL-600-1'A'	Test Plan	Aug. 15, 1963
LPL-770-1	Training Plan - LEM Ground Crew	Oct. 15, 1963
LPR-550-101	Monthly Failure Summary for Sept.	Oct. 10, 1963
LPR-250-8	Study Summary Report	Oct. 10, 1963
LPR-10-24	Monthly Progress Report for Sept.	Oct. 10, 1963
LPL-81-1A	Quality Control Program Plan	Oct. 9, 1963
LED-510-5	Test Plan - Solar Insulation	Oct. 15, 1963
LPL-635-2'A'	Support Plan	Oct. 14, 1963
LPL-540-1	Mission Plan	Sept. 27, 1963
LED-380-3	Communications Circuit Margin Report	Oct. 14, 1963
LPL-635-1'A'	Maintenance Plan	Oct. 14, 1963
LTR-904-16001	Landing Gear Stability Drop Test Report	June 9, 1963
	Landing Stability Demonstration Tests	Oct. 22, 1963
LED-380-4	Speech Intelligibility Criteria	Oct. 8, 1963
LLI-400-1	GSE Planning and Requirements List	Oct. 18, 1963
LPR-550-3	Quarterly Reliability Report	Nov. 1, 1963
LTR-905-14001	Tests of Pressure Vessels	Sept. 30, 1963
LPR-10-25	Monthly Progress Report for Oct.	Nov. 10, 1963

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Report no.	Subject	Report date
LED-1150-13	Ingress-Egress Study	Nov. 4, 1963
LPR-550-102	Monthly Failure Summary for Oct.	Nov. 10, 1963
LPR-250-9	Study Summary Report	Nov. 7, 1963
LTR-914-13001	Screening Tests of LEM Window Materials	Aug. 26, 1963
LED-360-9	Measurements List for LEM No. 1	Nov. 15, 1963
LED-570-5	Docking Simulation	Oct. 13, 1963
LPL-1150-8	Quality Control Plan	Aug. 17, 1963
LPR-3030-7	Study on Flight Attitude Table Dynamics	Sept. 30, 1963
LMO-570-150	LEM Progress Report - Rendezvous Simulation	Nov. 22, 1963
LED-490-4	Mass Property Report	Oct. 31, 1963
LPR-250-10	Study Summary Report	Dec. 10, 1963
LPR-10-26	Monthly Progress Report	Dec. 10, 1963
LED-520-1B	Design Criteria and Environments Report	Nov. 15, 1963

GENERAL DYNAMICS/CONVAIR
CONTRACT NAS 9-492

GD/C 63-193	Launch Vehicle Flight Report	Oct. 28, 1963
	Weekly Launch Site Activities Report	Sept. 23-27,1963
	Monthly Failure Summary	Oct. 2, 1963
	Monthly Quality Report	Sept. 27, 1963
	Quarterly Summary of Quality Audits	Sept. 30, 1963
	Weekly Launch Site Activities Report	Sept. 30- Oct. 4, 1963
	Weight and Balance Report No. 17	Oct. 1, 1963

Report no.	Subject	Report date
10864	Failure Analysis Report	
GD/C 63-209	Quarterly Progress Report	Oct. 10, 1963
12-03101	Attitude Control and Logic Amplifier Report	Aug. 21, 1963
12-04102	Similarity Qualification Test Report	
GD/C 63-034B	Launch Vehicle Description Manual	Oct. 1963
10953	Failure Analysis Report	
63-106	Qualification Test Report	June 4, 1963
GD/C 63-153	Narrative End Item Report	Oct. 7, 1963
CS-63-003	Launch Vehicle Familiarization Manual	Oct. 1963
10955	Failure Analysis Report	Oct. 15, 1963
GD/C 62-175D	Test Plan	Oct. 10, 1963
	Weekly Launch Site Activity Report	Oct. 14-18, 1963
T-12-25	Aerodynamic Heating	May 20, 1963
DC-12-009	LJII Failure Analysis	Oct. 1, 1963
	Weekly Launch Site Activities	Oct. 21-25, 1963
1086	Failure Analysis Report	Oct. 22, 1963
GD/C 63-220	Quarterly Reliability Status Report No. 6	Oct. 25, 1963
	Weekly Launch Site Activities Report	Oct. 28- Nov. 1, 1963
	Monthly Weight and Balance Report No. 18	Nov. 1, 1963
GD/C 63-193A	Launch Vehicle Flight Report	Oct. 28, 1963
	Monthly Failure Summary for Oct.	Nov. 4, 1963
	Monthly Quality Report	Oct. 31, 1963

Report no.	Subject	Report date
GD/C 63-223	Monthly Progress Report No. 12	Nov. 11, 1963
CS 63-040	Launch Vehicle Wire Data Manual	Sept. 1963
GD/C 63-072	Operations Manual	Aug. 1963
	Weekly Launch Site Activities Report	Nov. 8, 1963
GD/C 62-361	Qualification Summary	Nov. 15, 1963
	Weekly Launch Site Activities Report	Nov. 15, 1963
10330	Failure Analysis Report	Nov. 19, 1963
	Weekly Launch Site Activity Report	Nov. 22, 1963
DC-12-016	Test Report	Oct. 16, 1963
DC-12-017	Test Report	Oct. 16, 1963
SL-63-024	Test Report	Oct. 15, 1963
	Launch Site Activities Report	Nov. 25-29, 1963
GD/C 63-229	Design Engineering Inspection Report	
4680	Test Report, Noise Vibration	Aug. 13, 1963
189-A	Test Report	Aug. 10, 1963
22C-63060	Test Report, Attitude Control System	Nov. 1963
	Test Report	July 23, 1963
DF-12-115A	Test Report	Nov. 29, 1963
GD/C 62-157	Contract Data Summary	Nov. 15, 1963
PM-12-365	Index of LJII Documentation	Nov. 1, 1963
	Monthly Weight and Balance Report No. 19	Dec. 2, 1963
	Monthly Failure Summary	Dec. 4, 1963

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Report no.	Subject	Report date
	Monthly Quality Report	Nov. 29, 1963
	Launch Site Activities Report	Dec. 2-6, 1963
GD/C 63-085	Launch Vehicle Operation Manual	Dec. 13, 1963
10332	Failure Analysis Report	Dec. 3, 1963
	Launch Site Activities Report	Dec. 9-13, 1963
GD/C 63-288	Launch Operations Schedule	
	Launch Site Activities Report	Dec. 23-27, 1963
GD/C 63-196	Qualification Status List	Dec. 15, 1963

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NASA-S-64-1713

[redacted]

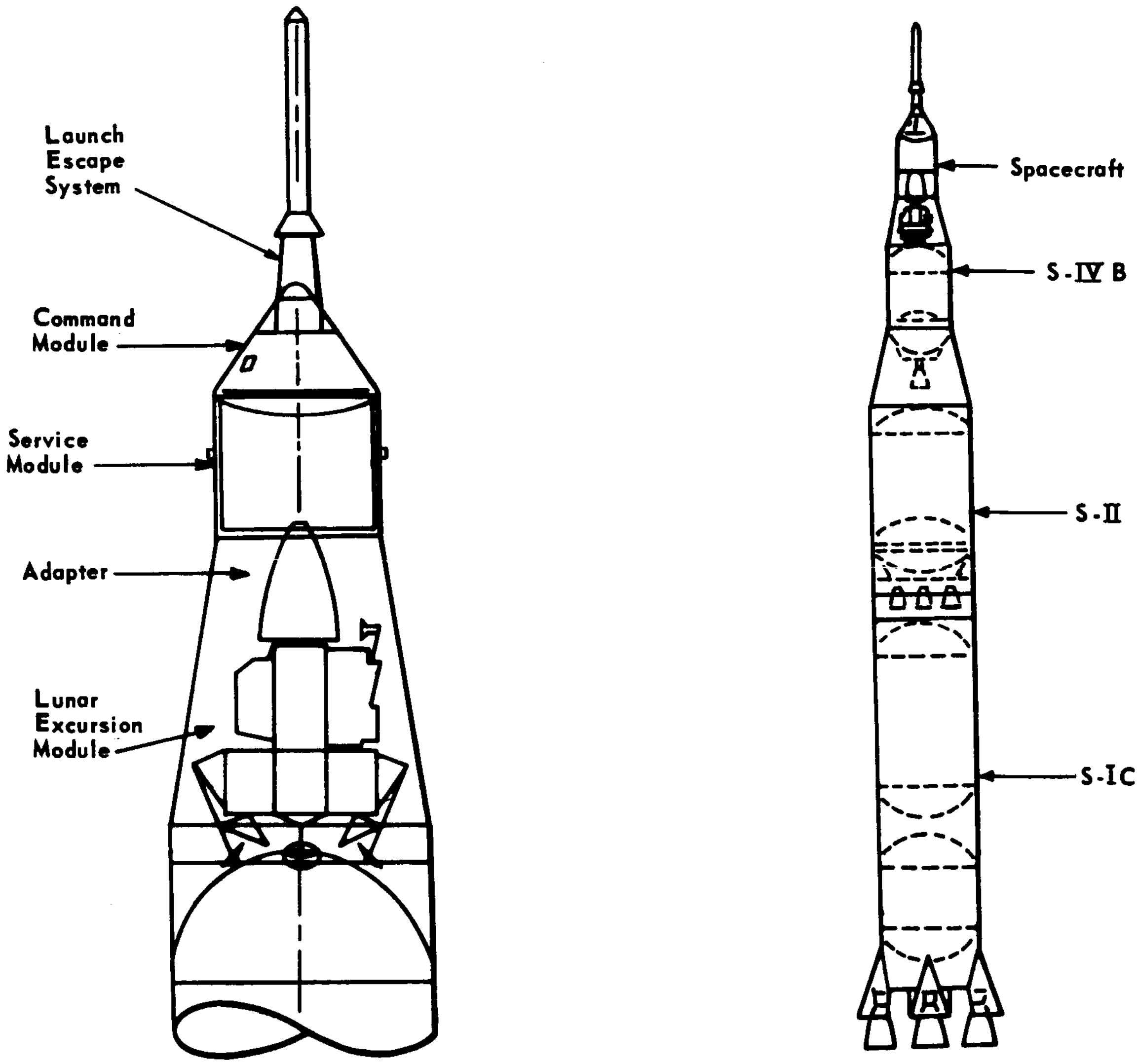

Figure 1 - Apollo space vehicle configuration

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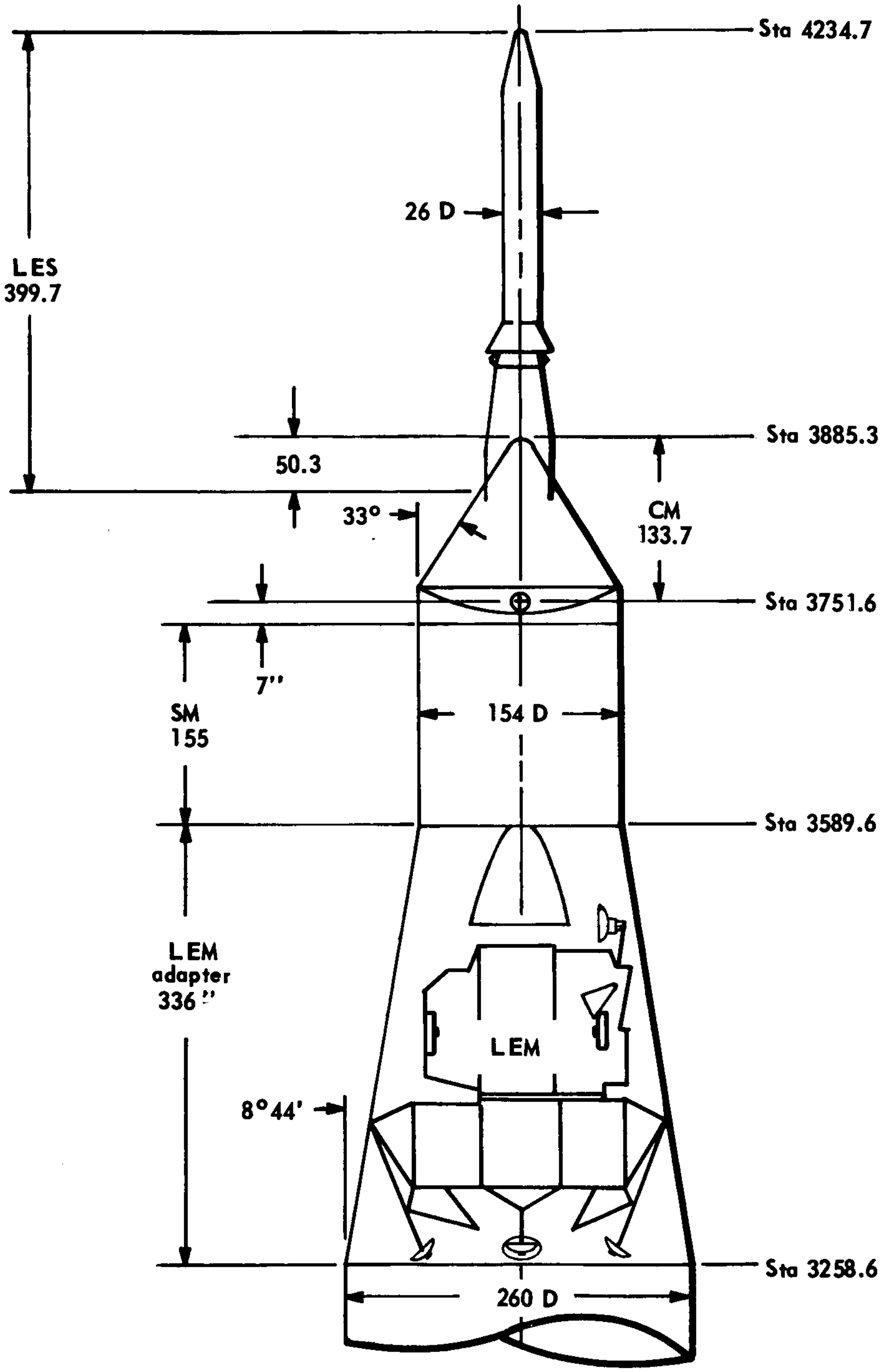

Figure 2 - Apollo spacecraft configuration

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[redacted]

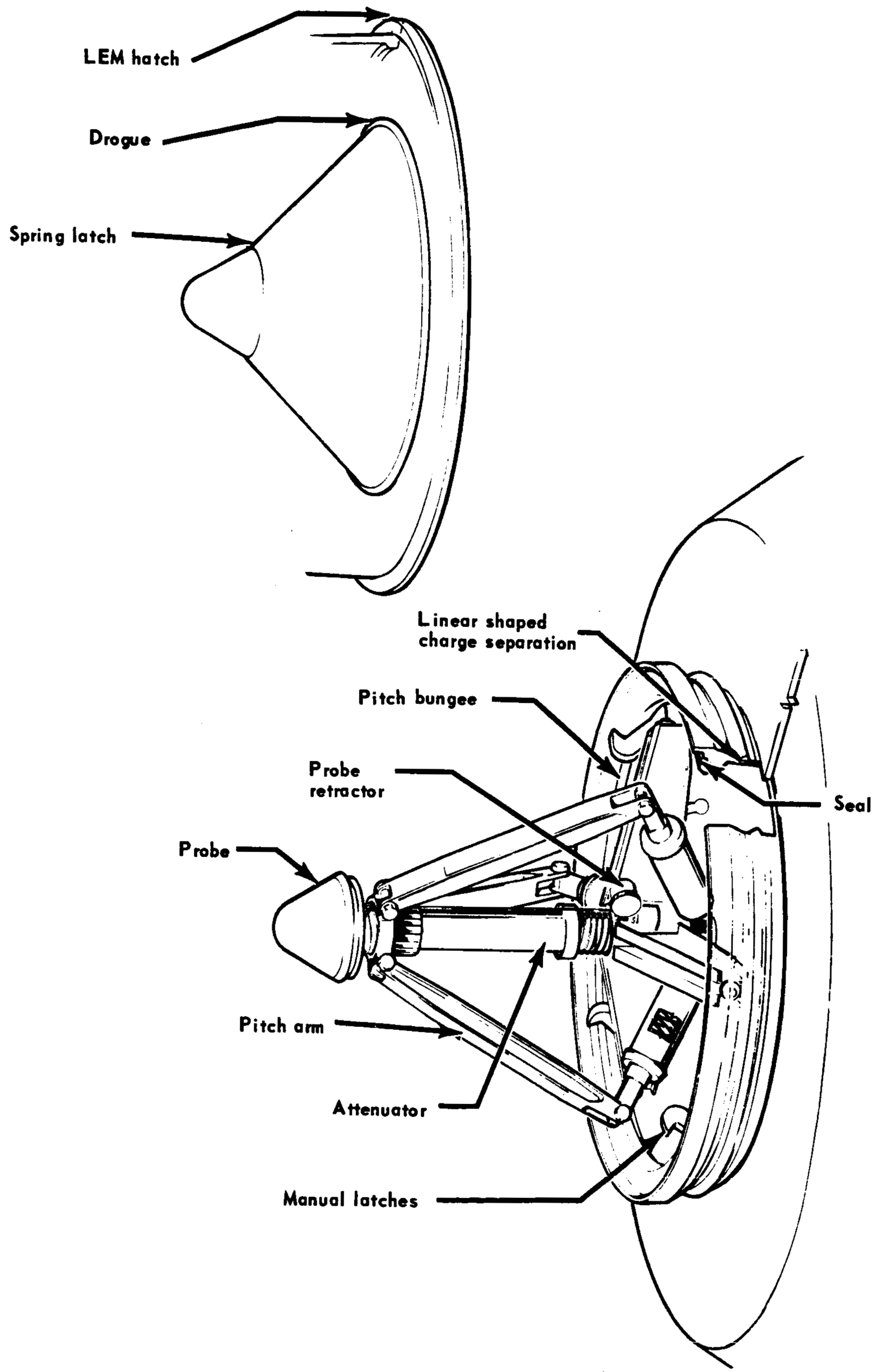

Figure 3.- Probe and drogue concept

[redacted]

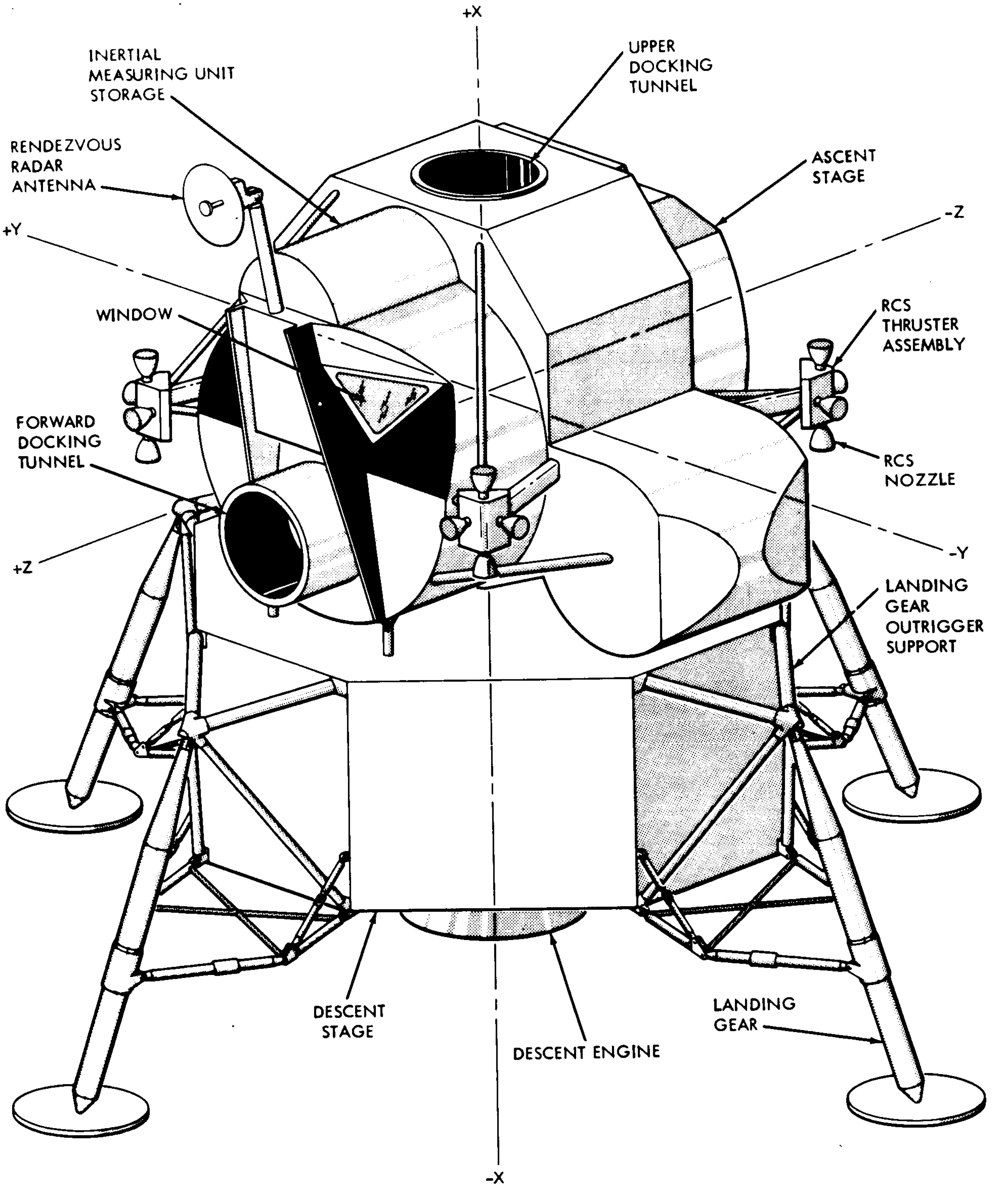

Figure 4.- LEM structure

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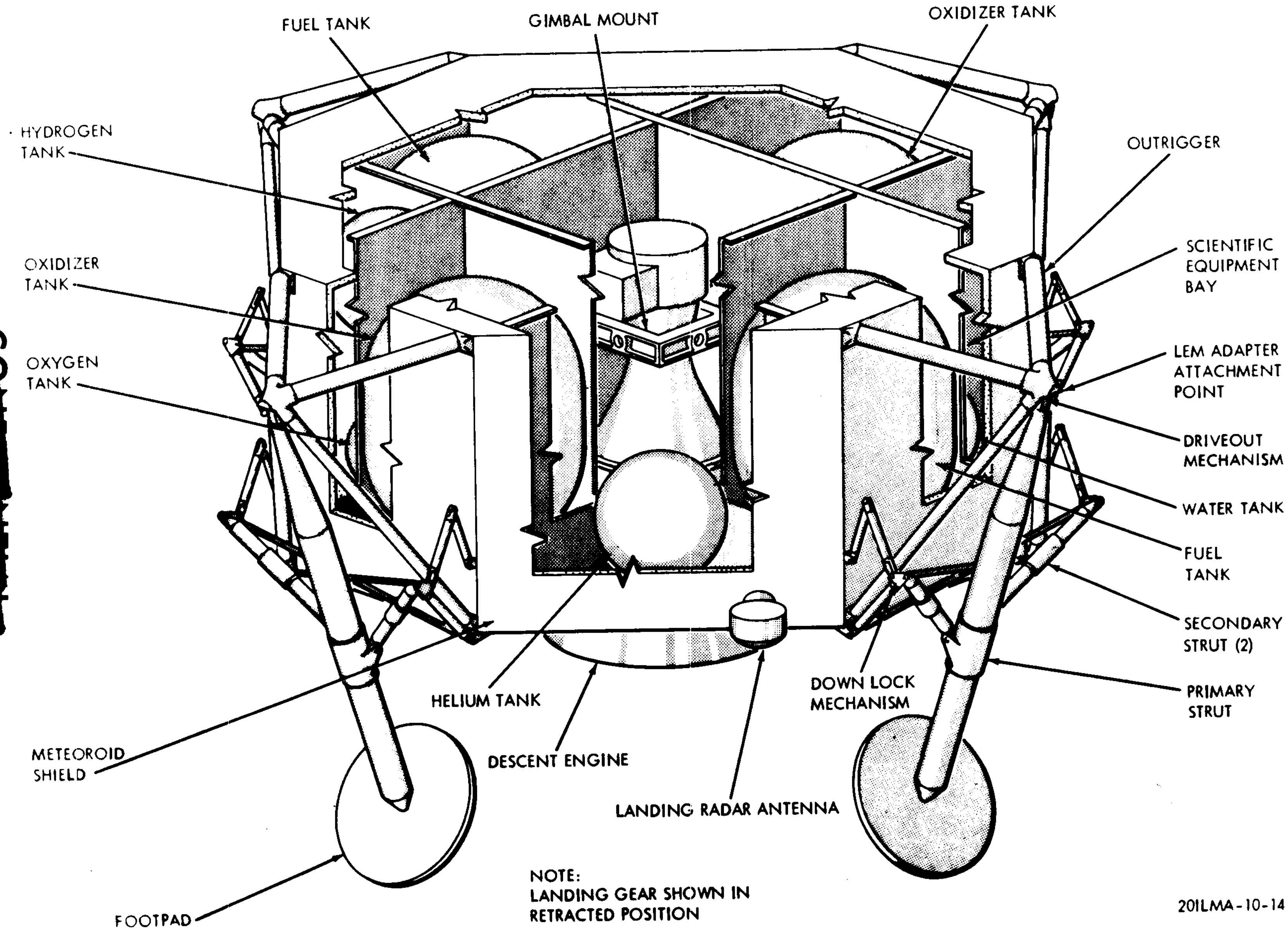

Figure 5. - Descent stage

[redacted]

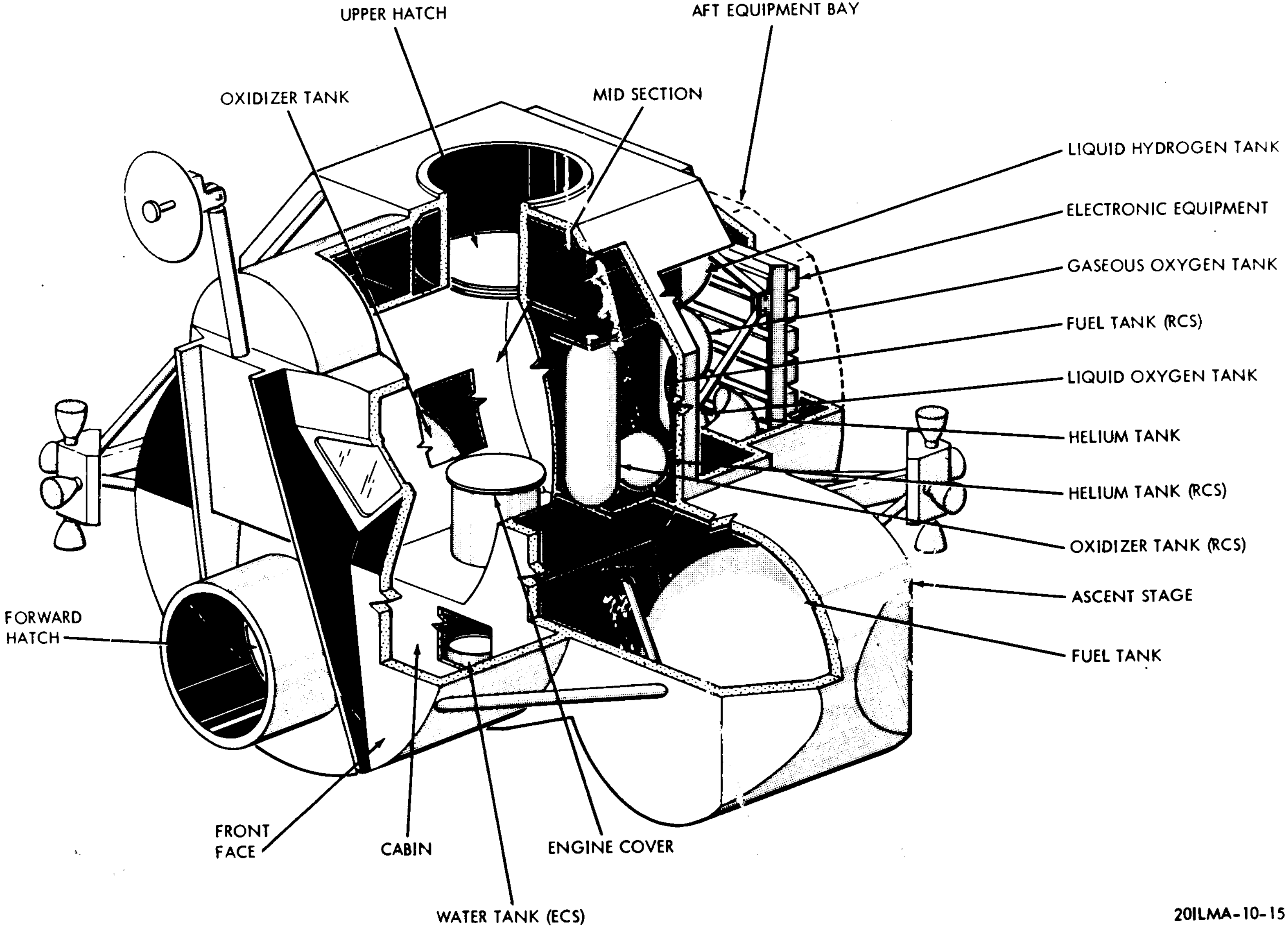

Figure 6. - Ascent stage

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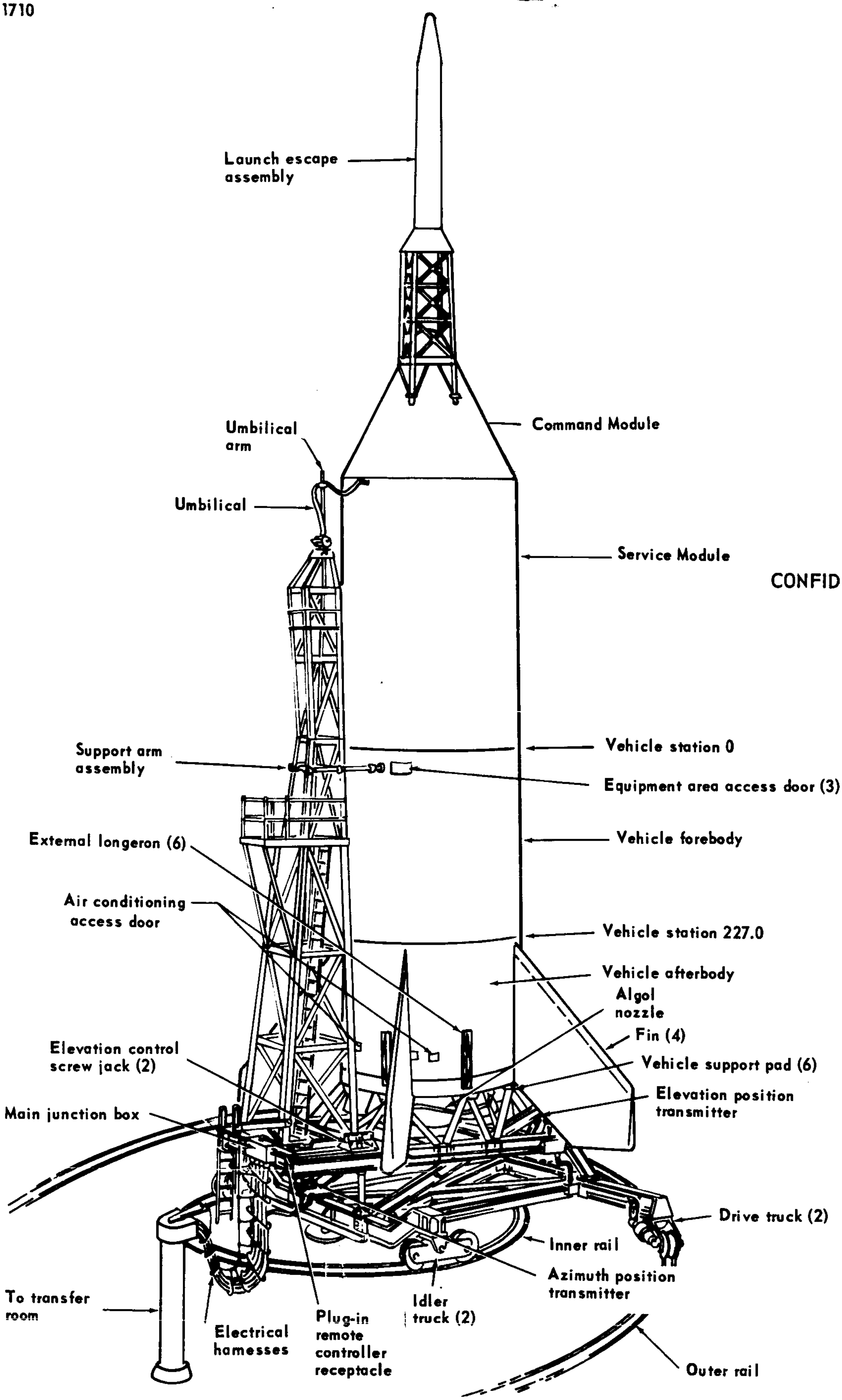

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Figure 7.- Little Joe II launch vehicle and launcher

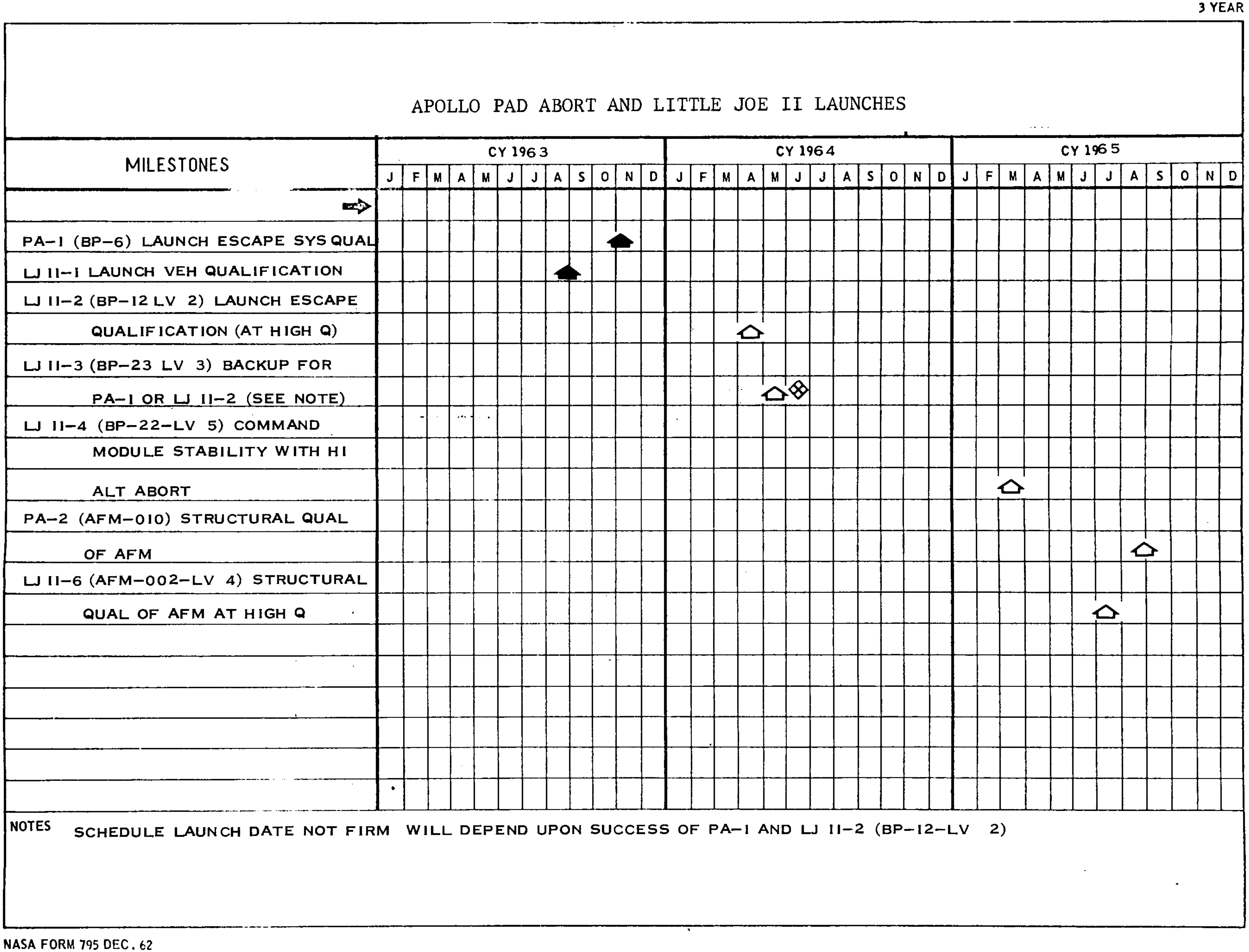

Figure 8.- Apollo pad abort and Little Joe II launches (As of December 31, 1963)

[redacted]

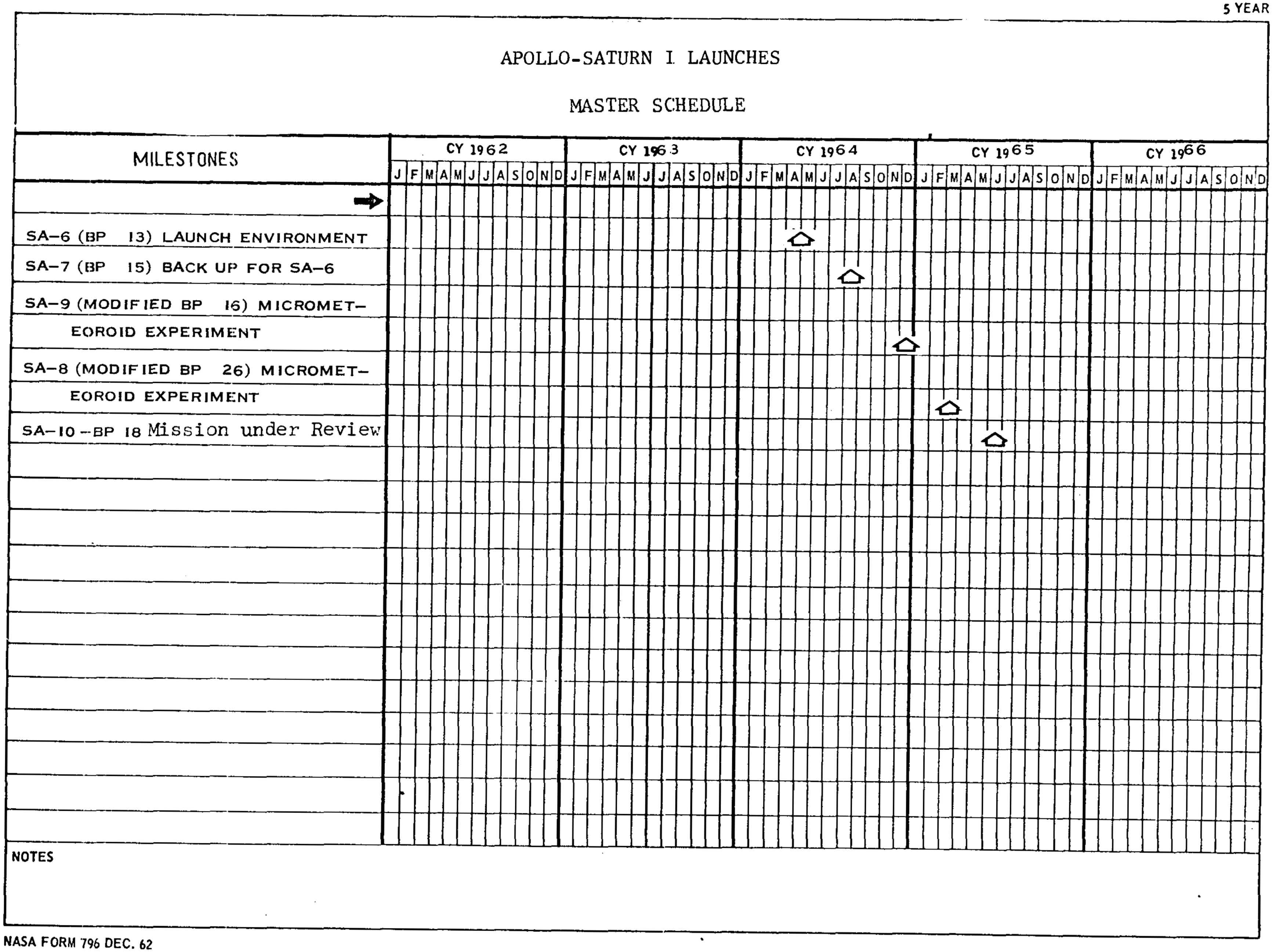

Figure 9.- Apollo Saturn I launches (As of December 31, 1963)

[redacted]

[redacted]

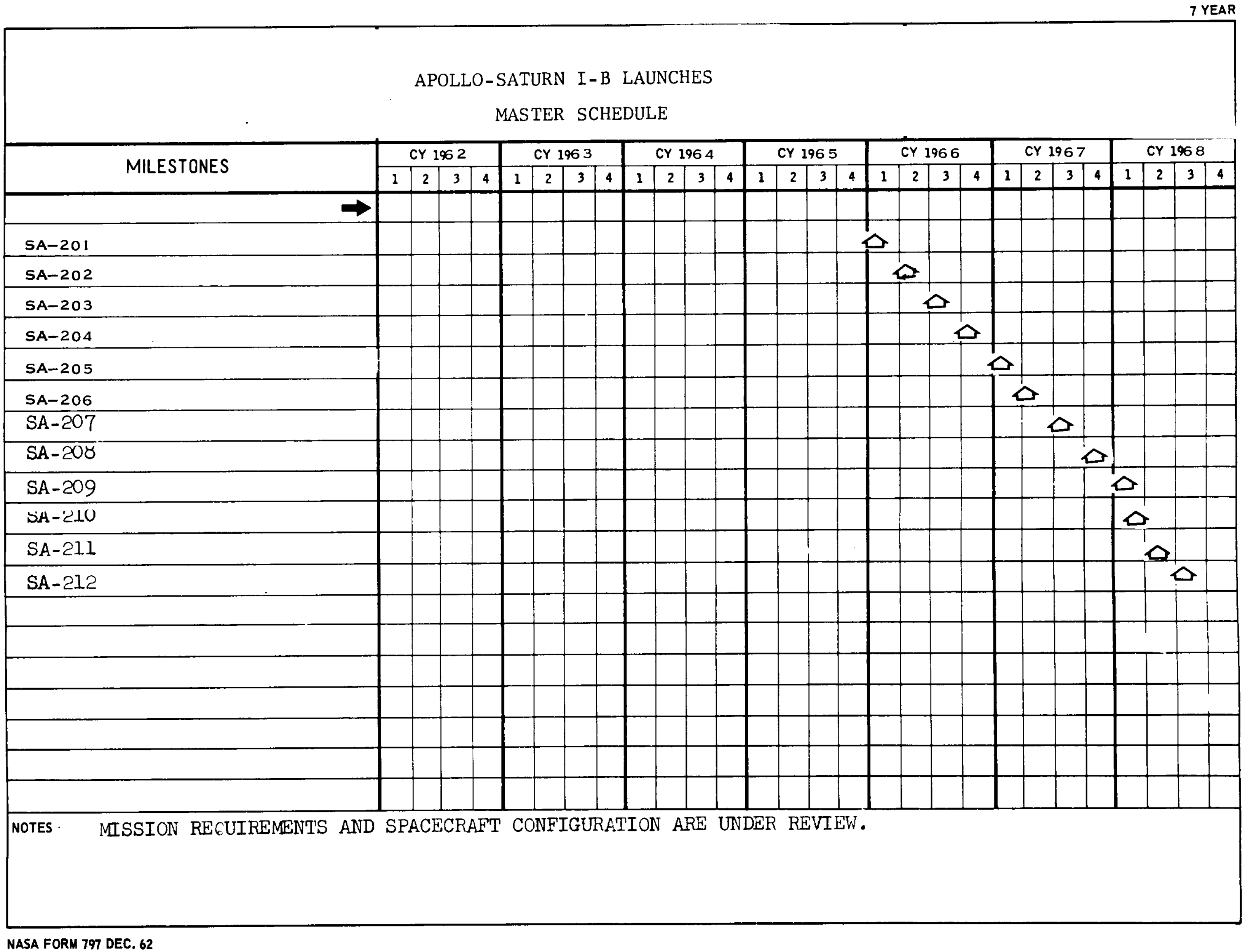

Figure 10.- Apollo Saturn I-B launches (As of December 31, 1963)

[redacted]

[redacted]

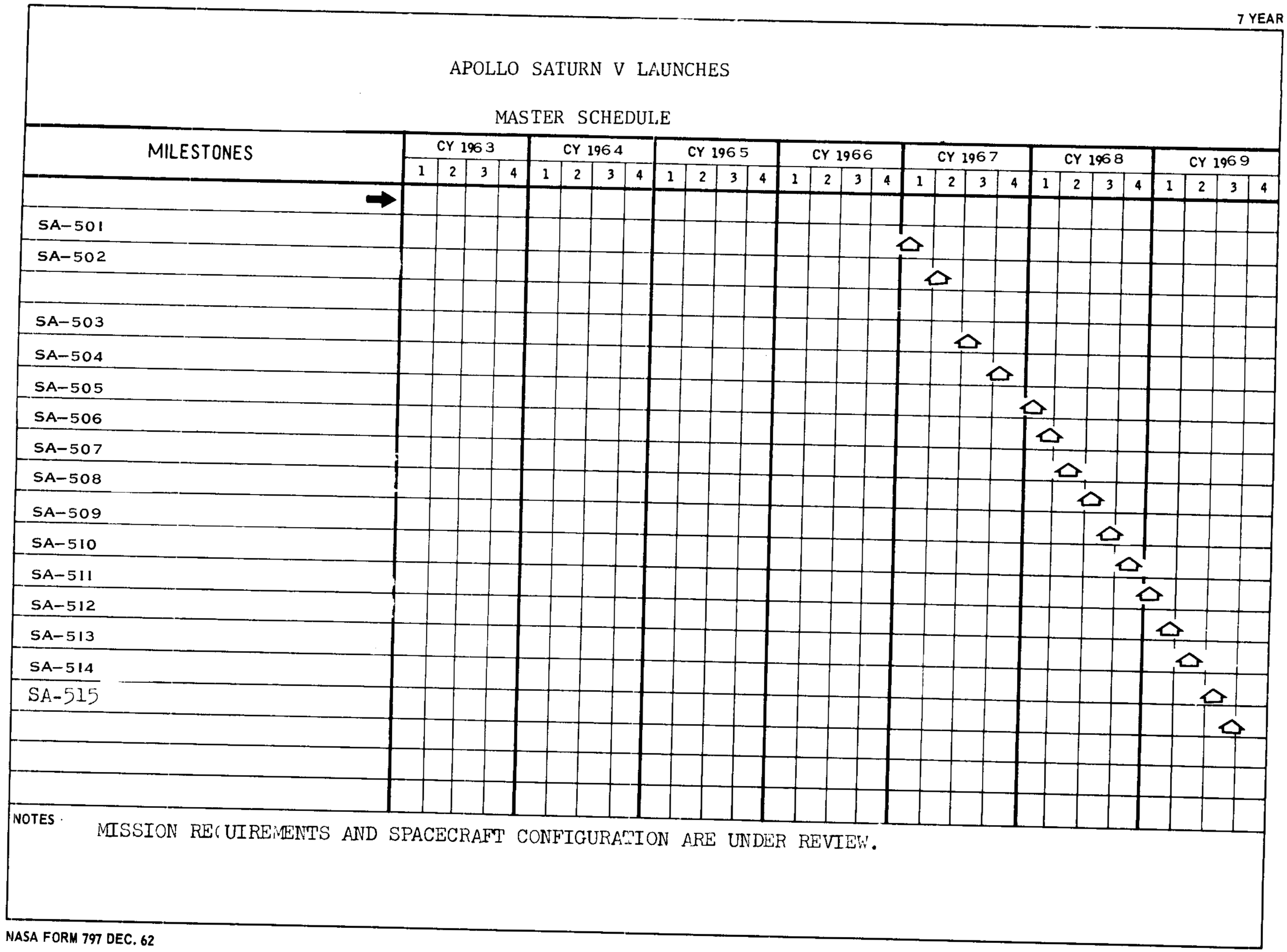

Figure 11.- Apollo Saturn V launches (As of December 31, 1963)

[redacted]